

REPORT

OF THE

GEOLOGICAL RECONNOISSANCE

OF THE

STATE OF VIRGINIA.

MADE UNDER THE APPOINTMENT OF THE BOARD OF PUBLIC WORKS.

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PHILADELPHIA:

DESILVER, THOMAS & CO.

1836.

REPORT.

GENTLEMEN,

I beg leave to present the following report of the geological reconnoissance of the state of Virginia, authorized by an act of the legislature, bearing date March 6th, 1835, with the execution of which I have had the honour to be entrusted.

In the prosecution of this duty, while my attention has not been withheld from such observations of a minute and detailed description as opportunities occasionally threw in my way, it has been chiefly directed to the legitimate objects of such a reconnoissance, namely, the general geological and mineralogical features of all the important divisions of our territory, with a view to exhibit the benefits to be derived from a detailed survey, and the mode of conducting it best adapted to develop the structure and resources of the state. Although in the course of these inquiries many new observations have been made calculated to prove extensively advantageous, numerous matured discoveries were not to be anticipated, considering either the design of the reconnoissance or the very general nature of the investigations which are appropriate to an examination strictly preliminary in its character. Inquiries of a more minute description, extended to all the divisions of the state, would obviously have been impossible, and until some scheme of systematic investigation in detail is put in operation, comparatively of little value. With such views, it is thought that the objects of the reconnoissance are accomplished, in exhibiting the prominent geological features of the great divisions of the state, the more important natural resources dependent upon their mineral structure, and in pointing out in relation to each the various desiderata to which future inquiry may be beneficially directed.

MODE OF CONDUCTING THE RECONNOISSANCE.

With the view of exhibiting clearly the geological structure and relative extent of the various formations in the state, as far as ascer-

tained during this reconnoissance, it was important to construct what is termed a *geological section* or *profile*, from actual observations made from point to point in one or more lines transverse to the general ranges of the strata; thus combining in one view, all the most important mineral formations of the state, together with their prevailing order of succession, and their relative inclinations, or the angle in which each inclines to the horizon. The general line of observation selected for this purpose, extends from Hampton Roads to the mouth of Guyandotte. A belt of country of variable breadth, spreading to some distance on either side of this line, was the more immediate subject of investigation, and furnished the materials from which the geological section appended to the present report was constructed.

In prosecuting the examinations necessary for this purpose, no one line of observation was rigorously adhered to, but numerous local profiles were first formed, and thence by a reference of them all to the general line already specified, the entire profile was formed, which is now presented. It is, therefore, tendered at this time only as an approximate delineation of a transverse geological section of the state, and as such, though sufficiently accurate for the purposes of occasional reference in the present report, lays no claim to the minute precision of geological profiles constructed from the accurate data of a *detailed survey*. Several minor belts also transverse to the general ranges of strata, and remote from the former, were likewise examined, and particular profiles constructed from the data thus obtained. One of these extends in a general direction from the White Sulphur springs, by Covington and Lexington to Buckingham courthouse; a second from Columbia, by Charlottesville, Turk's and Rhodes' gap, and Harrisonburg, to the North mountain; and a third embraces a portion of the Potomac. In addition to these transverse lines of observation, several routes have been explored more nearly conforming to the bearing or direction of the strata. One of these extends in a general direction from Halifax, on the Roanoke, to the lower falls of the Potomac, and is nearly coincident with the western boundary of the tide water or tertiary section of the state. Another embraces a general view in the longitudinal direction of the valley of Virginia, from the Potomac to the James river, &c. Beside these, many other lines of observation were examined, some of them embracing a distance of 50 or 60 miles, on either side of the general route. Keeping in view the im-

portant practical inquiries appertaining to the reconnoissance, as much local information of a useful nature has been obtained on each excursion, as was consistent with the time which could be devoted to investigations of a special character. The general nature of the observations contemplated in the reconnoissance, and the necessity of rapid movements when so great a breadth of formations was to be traversed, rendered much delay in minute local observations inexpedient, on which account many points of great practical interest will be excluded from the report, which might otherwise have been introduced. These would be among the proper subjects for inquiry in a detailed survey.

In regard to the tide water section of the state, it is proper to remark, that through some previous attention to its geology, I am enabled to present a somewhat minute account of its important features, as observed in several large and interesting districts which I have explored. Among which, I would specify the peninsula bounded by the York and James rivers, and many of the counties on either side. More recently, and in connexion with the reconnoissance, I have examined the country on both sides of the Pamunkey, from the junction of the North and South Anna to its mouth, and have extended my inquiries with some success into similar formations south and north as far as the James river and the Potomac. The discovery of a material likely to prove valuable to the agriculture of that section of the state, may, without impropriety, be referred to as an illustration of the utility to be expected from minute geological inquiries, directed to every portion of our territory.

But in addition to the duty of exploration performed according to the plan which I have now described, I have devoted some time to the chemical analysis of rocks, ores, earths, marls and mineral waters. In relation to this department of my duties, however, it is easy to perceive, that the tedious nature of such investigations, would preclude the completion of many accurate analyses within the period allotted to the reconnoissance; but a variety of useful chemical results have been obtained, which as far as compatible with the scope and objects of this report will be detailed in the following pages.

GENERAL GEOLOGICAL DIVISION OF THE STATE.

For the sake of exhibiting under one view, each group of analogous formations, the whole territory of the state may be conveniently

divided into five principal regions. These we will treat of in a geographical rather than geological order; first defining the limits of each respectively, with as much precision as in the imperfect state of knowledge on the subject can be attained, and then in general terms describing the geological features by which they are, to a certain extent, severally distinguished.

(1.)—The first of these, which may be called the *tertiary marl region*, embraces nearly all that portion of the state included between its eastern boundary, the Chesapeake bay and the Atlantic, and a hypothetical line intersecting the principal rivers at their lowest falls. Various beds of clay and sand, nearly horizontal in position, abounding in fossil shells, and the remains of large marine animals, form the characteristic strata of this division of the state, while occasional bands of iron ore, and beds of green sand, and a small portion of gypsum, occurring in connexion with one of the fossiliferous deposits of the region, are among its other materials of value.

(2.)—The second division is comprised between the hypothetical line above mentioned and the western flank of the *Blue Ridge*—including under this title the range very improperly denominated the Alleghany mountain in Franklin and Patrick counties. According to the delineation of Mr. M'Clure, by whom the first attempt was made at marking out the great geological divisions of North America, the rocks of the Blue Ridge and a narrow adjacent belt of territory should be regarded as belonging to the primary system of geologists—while a large portion of the area between this and the belt of unequivocally primary character which ranges along the lower falls of our rivers on the east, is to be looked upon as the equivalent of the old red sandstone rocks of Europe. Others who have attempted to sketch the outlines of our principal geological formations, have with even less approach to accuracy, confounded all these strata under the sweeping denomination of primary—and have thus given to the diversified and extensive region whose limits are above described, the distinctive appellation of the primary region of Virginia. Such a view appears to have been adopted by the authors of the map of our state, the brief geological sketch appended to which describes the Blue Ridge as the western boundary of the primary. A more recent writer also, professing to derive his views from an actual examination of the structure of this mountain, has contributed to confirm the prevailing error by proposing as an appropriate name for the Blue Ridge—the title of the Atlantic primary chain. It is deeply

to be regretted that while so little has been done towards a minute exploration of the diversified and complex formations of the region now in question, the writers who have attempted to describe it, and more especially those who have professed to give a scientific exposition of its character, should have observed so little caution in the application of names, and have indulged so much of the spirit of superficial and precipitate generalization. There is no division of the state which presents greater difficulties to the geological inquirer, than the region here referred to, and none which will require for its elucidation more minute and patient investigation. The observations respecting some parts of it, which will be presented in the body of the report, imperfect as they necessarily have been, were directed in part to the determination of some of the difficult problems which this portion of our geology presents—and although insufficient to remove the difficulties in which the subject is involved, will, it is believed, lead to several interesting and important views of a scientific as well as practical nature, while they overthrow the errors which, either through ignorance or inadequate investigation, have hitherto existed. So far from regarding the whole area in question as of a primary character, these observations conclusively demonstrate that the extent of the rocks, to which that title may be unequivocally applied, bears but a small proportion to the whole surface of this division of the state—and while they render it doubtful whether in the Blue Ridge any truly primary rocks occur, they evince the existence in that range, as well as throughout a very extensive district to the east, of sandstones, conglomerates, and other sedimentary deposits, unquestionably referable to a different period of formation.

The gold region, so remarkable for its extent and richness, and the bituminous coal fields of Chesterfield, Goochland, Powhatan and Prince Edward, constitute important divisions of this region of the state, while the slates and soapstones, iron ores, limestones, and other minerals which it includes, are objects of practical as well as scientific interest. To all of these a proper place will be allotted in the body of the report.

(3.)—Our third general division, commencing near the western flank of the Blue Ridge, comprises all the region generally called the Valley, extending westward in the counties of Berkeley, Frederick, Shenandoah and Rockingham, to the base of the several ranges called the Little North mountain, in Augusta and Rockbridge, nearly to the base of the North mountain, and in the counties further south, occupying

an area, which, for the present, does not admit of being accurately defined. Limestone strata of vast extent, hydraulic lime, marble, travertine or deposit marl, slate, iron ore, and in the south, lead ore, are among the valuable materials included in this section of the state. Declining to apply the title of *Transition* to the strata of which this region is composed, because much additional observation is required for the determination of their true geological relations, we must for the present be content with referring them to the oldest of that group of rocks in which the organic remains or fossils have been discovered.

(4.)—The fourth general division to which we shall refer is, at present, even less susceptible than the preceding, of being defined by lines of precise limitation. Nearly the whole of its surface is occupied by chains of mountains, and extremely little has hitherto been done towards exploring its geology. In general, it may be described as comprised between the western limits of the great valley formation and the front ridge of the Alleghany, the Greenbrier and Muddy creek mountains; but with regard to its extent and boundaries further south, nothing definite can be affirmed until it shall have been carefully and systematically explored. Besides the interest in a scientific point of view which attaches to this region, on account of the peculiar structure of its mountains, the stupendous natural sections which it exposes, and the astonishing abundance and variety of the fossil impressions found among its rocks, it claims a high importance from the great value of its materials, economically considered. Its anthracite, pseudo-anthracite, or semi-bituminous and bituminous coals, its limestones, sandstones and grits, and iron ores, and its numerous thermal, chalybeate and sulphuretted springs, constitute collectively an amount of mineral treasures of which few other territories of the same extent are as largely possessed. Without, at present, venturing to apply any precise geological designation to this singularly interesting region, it will be shown to have marked peculiarities which distinguish it from the division previously described.

(5.)—Our fifth and last division, stretching from the eastern limits of the former to the western and south-western boundaries of the state, presents an area of vast extent, and embraces regions abounding in materials of the highest economical utility.

This immense territory, characterised by nearly horizontal strata, gently dipping towards the west refers itself unequivocally to the

group of secondary rocks—and from the numerous and rich beds of bituminous coal which it includes, may with strict propriety be denominated the great secondary bituminous coal region of Virginia. Besides its numerous and widely stretching strata of the above-mentioned material, this favoured region possesses the additional treasure of a saline formation of immense extent, towards its western boundary—and if the limits of the region are not improperly assigned, a similar formation, accompanied with gypsum and other valuable minerals in the south-west corner of the state.

(6.)—Pursuing the order in which the several divisions of the state have now been sketched, the *Tertiary marl region* will first claim our attention.

TERTIARY MARL REGION.

The extensive area embraced in this division of the state, though presenting comparatively little diversity in external aspect, includes strata, which, by their fossil contents, unequivocally refer themselves to two distinct geological periods, though they are all without doubt comprised in the general class of tertiary formations. Adopting the names which have been recently applied in Europe to parts of the tertiary series, to which the strata referred to may be regarded as probably equivalent, though without implying any conviction on our part, that such equivalence is in general to be expected in the two continents, we shall indicate by the term *Miocene* the strata which occur in the eastern and greater portion of this region, and from which the ordinary shell marl is procured, while we will apply the name *Eocene* to the deposit of an older date existing beneath and west of the preceding, containing fossils of a different character, and characterised by the prevalence in considerable proportion of the peculiar mineral called *green sand*.

The first of these, or the *Miocene marl district*, comprehends all the area from the seaboard or water boundary of the state on the east, to a line conceived to be drawn through Northbury on the Pamunkey, and Croggin's point on the James river, in a direction nearly meridional, but through what precise points, further observations are necessary to determine.

The other or *Eocene marl district* is comprehended between the imaginary line above described and another line passing from the mouth of Acquia creek, through Wales, at the junction of North and

South Anna rivers, and thence through City Point, and further south in a direction not yet precisely ascertained. Much of the district here defined exhibits Miocene as well as Eocene marl, the former being found either in highlands remote from the rivers, or in the superior parts of the river cliffs overlying the latter. The localities above named were selected as points marking the eastern boundary of this region, because at those places the Eocene marl was observed to disappear below the water line by a gentle dip to the east. Its existence extensively beneath the Miocene district may be looked upon as highly probable, though under what circumstances as to depth and inclination of the beds, we have no positive data to determine.

MIocene MARL DISTRICT.

In the most eastern portion of this division of the tertiary, the general level of the surface is but little elevated above tide. The country is a uniform flat, in some places subject to be occasionally overflowed. The rest of the region in question has an elevation above tide, varying from twenty to eighty feet. But few points, however, in the district have a level corresponding to either of these extremes, and by far the larger portion of the surface preserves a height of from forty to fifty feet. ✓

The surface of this more elevated portion, though preserving a general level of remarkable uniformity, is deeply channelled by innumerable ravines. The smaller of these connect themselves with large ones, and these with the wider and deeper excavations forming the beds of the creeks flowing into the neighbouring rivers. The system of ravines connected with one river are separated by a narrow central tract from those connected with the next, and in a general view of the district, these systems present the appearance of mere creeks or inlets subordinate to the great rivers by which this region is broken into peninsulas. The number and extent of the large rivers and the navigable streams of this portion of the state, constitute the most inestimable of its natural advantages. The numerous creeks indenting its peninsulas furnish the cheapest and readiest avenues for a commerce which comes home to the abodes even of its rural inhabitants, while its surface scooped into ravines and its river cliffs washed by the tides, disclose the rich materials which are hereafter to bestow the highest rewards

upon its enterprise, by spreading fertility and wealth to its remotest boundaries.

The superficial stratum of the region we are describing is an argillaceous and ferruginous sand of a yellow and sometimes of a reddish colour, in which are occasionally found at or near the surface, pebbles and small boulders of sandstone, rarely as much as six inches in diameter. The nature of these boulders would indicate that they were most probably derived from the sandstone formation which ranges along the eastern boundary of the primary ridge. In some places this stratum consists of little else than a white silicious sand; in others, the admixture of ochreous clay is so considerable as to furnish a suitable material for the manufacture of bricks.

Beneath this superficial layer, beds of a very argillaceous clay occasionally occur, sometimes of considerable depth and extent, and of a texture to be useful in puddling. Its colour is various, being in some places a dark blue or green, in others a bright red or dingy yellow. Wherever found, its upper boundary is remarkably even and horizontal; but where it rests upon beds of fossil shells, its lower limit conforms to all the irregularities of surface which those beds usually present. Its appearance, in some places, is that of a steep, almost perpendicular wall of smooth surface, and divided by very narrow lines running horizontally. These narrow lines, at a distance of from five inches to a foot asunder, are formed by a more ferruginous and silicious clay. At Bellefield, on the York river, seven miles from Williamsburg, this deposit may be seen overlying the stratum containing shells, in some places having a thickness of from twelve to fifteen feet, and then gradually fining out and passing into a light coloured and coarser mass. The upper surface is horizontal, and the lines of division above alluded to are perfectly parallel and regular. The lower surface of the clay conforms to that of the shell stratum upon which it rests. In many places these argillaceous beds consist of a yellowish clay, beautifully variegated by streaks of red and blue. In some places there exists a slight impregnation of alum and copperas in these beds of clay. This is particularly the case in some localities on the Rappahannock and the York and Chickahominy rivers. The proportion of these ingredients is, however, not sufficiently great to entitle these strata to attention in an economical point of view, although it is fully sufficient to impart a very ungrateful flavour, and perhaps some useful medicinal properties to the springs and wells of the neighbourhood.

A thin stratum of red ferruginous stone, containing a large proportion of oxide of iron, is found in this region, running horizontally below, and sometimes in the beds of clay before described, and generally separated by only a few feet from the underlying masses of shells. This stratum, which is very generally present, varies in thickness from an inch to a foot. Its texture is sometimes cellular, sometimes compact and fibrous, like that of certain varieties of hematite. In the more eastern portions of the Miocene district, the peculiar structure of which will be hereafter described, much ore of this description lies loosely scattered on the surface; while in the more elevated parts of the country, its invariable position is such as above described. The character of the ore in many localities is such as to promise great facility in reducing it to the metallic state, together with a large per centage of resulting metal. A specimen obtained from above the marl on the cliff at Mount Pleasant, Surry county, yielded by analysis in the 100 grs.

per oxide of iron,	72.40
alumina,	3.90
silica,	7.71
water,	14.35
	98.36
Loss,	1.64
	100.00

With a sufficient supply of ore like this, accompanied with the advantage of a shell limestone sometimes beautifully crystalline, in its immediate vicinity, the manufacture of iron would promise a high degree of productiveness; and it is by no means improbable that in some parts of this region the supply of the ore may be found sufficient to make such an enterprise not only safe but profitable. The subject is at all events worthy of some attention. Indeed it appears not a little surprising that this rich mineral seems hitherto to have escaped observation, or at least to have been regarded as undeserving of an especial notice.

In some places, as for example, in Essex county, chiefly upon the ridge land, beds of a ferruginous sandstone are found of sufficient extent to be used as a building material. This rock is not to be confounded with the sandstones which occur some distance to the west of this, on the borders of the primary region, but it is to be

looked upon as in the case of a very similar material recently made the subject of minute inquiry by my brother in New Jersey, as a remnant or outlying portion of a once somewhat extensive deposit of ferruginous gravel and conglomerate, which by subsequent denuding action has been almost entirely removed.

The matter which in most cases rests immediately upon the shells, is a yellowish brown sand, frequently containing a large proportion of clay. Throughout this mass, and often extending to the distance of five or six feet from the shells, particles of green sand, or the silicate of iron and potash, are more or less abundantly disseminated; and in the immediate vicinity of the shells, these particles are generally condensed into narrow stripes conforming in flexure to the irregularities of the bed beneath. Even where a deep hole exists in the layer of shells, the stripes of green sand are seen still following the depression and rise of the surface, and preserving a uniform distance from it. Sometimes these thin layers are so much indurated as to have almost the appearance of stone. In none of the strata above described have fossils of any description ever been discovered.

The materials with which the shells are intermixed, or in which they are embedded, have various characters. In some cases they consist principally of a nearly white sand; in others the argillaceous matter greatly predominates, and the mass is a somewhat tenacious clay. Frequently much oxide of iron is mingled with the earthy matter, giving it more or less of a yellow or brown appearance, and this is the aspect which the upper beds containing shells most usually present. Very generally the lowest visible fossiliferous stratum is composed of a green silicious sand, and a bluish clay, which being always very moist, is soft and tenacious, and presents a dark blue or black colour. At the base of the cliffs on the James and York rivers, this stratum may be traced continuously for considerable distances, rarely rising more than two or three feet above the level of the water, and presenting an even horizontal outline. In the deep ravines, and low down in the banks of shells, generally, throughout this region, a similar dark bluish green argillaceous sand is observed, enclosing frequently a great number and variety of shells. This constitutes what is usually denominated *blue marl*, which from the soft condition of the shelly matter which it contains, as well as the predominance of clay in its composition, is found peculiarly beneficial when applied to the more arenaceous

varieties of the soil. Many highly valuable marls extensively in use are of this description.

The very general existence of the lower stratum, above described, forms an interesting and prominent feature in the geology of the Miocene Tertiary districts, as well of eastern Virginia as of Maryland. Throughout all the upper fossiliferous strata, as well as in the argillaceous beds just mentioned, will be found disseminated, greenish black grains of *Silicate of iron and potash*, identical with those already described as existing in the stratum immediately overlying the shells, and having the same form and composition with the granules contained very abundantly in an older formation, both in this country and in Europe. In some beds of the marl or shells, these particles so abound as to give a very decided colour to the whole mass. In specimens from James City and York counties, as much as thirty-five per cent. of the green sand has been found, and occasionally shells are seen filled with this substance almost alone.

The surface of the strata containing shells is usually irregular. Sometimes it rises abruptly, in the form of a hillock, then it is scooped out into depressions of a few feet in depth. These irregularities, however, are apparently of two kinds; the one the original form of the deposite, the other produced by denuding action upon the surface. Thus in many places the same stratum may be remarked, rising with more or less abruptness, then again descending, and perhaps preserving a nearly horizontal line for some distance, marked at its upper surface by a clear and unbroken outline, and presenting no indication of violent abrasion from above. In other places, and this is a very frequent occurrence, deep and irregular furrows and cavities are seen, such as would naturally arise from the action of the currents and eddies of a large mass of water in rapid movement. Whether from this cause, or from the gradual dissolving action of percolating water, *sinks* exist in this region in many places, though they are by no means as numerous or extensive as in the limestone districts.

Having thus given an account of the nature and arrangement of the strata overlying the shells, as well as those in which they are embedded, we will now describe the general condition and disposition in which the shells occur.

CONDITION OF THE SHELLS IN THE TERTIARY DEPOSITES.

In general the state of the shells, and their arrangement in the earth, are such as to indicate their tranquil deposition at the spots in which they are found. Thus the corresponding valves are very often found together and closely shut. Many of the smaller shells, such as *Arca centenaria*, *Arca incile*, *Nuculæ*, *Venericardia alticosta*, and *Chama congregata*, which are most usually found thus, are often either entirely empty, or contain a small quantity of clay that is quite impalpable, indicating plainly that they have been exposed to no violence, and that only such solid matter as could pass between the edges of the closed valves had obtained access to the interior. Whenever such shells, however, have been previously drilled, as is very frequently the case, even with the largest and thickest shells, the interior is found entirely filled with sand, clay, green sand, and small fragments of shell. In most cases the larger species of shells, even when their valves appear to be in accurate juxtaposition, is thus filled, and in this case it cannot be supposed that the contained matter has entered through the holes thus drilled, since in many instances shells of considerable magnitude are found imprisoned within. Such shells, no doubt, after the death of the animal, remained open, or at least partially so, and received the sand, clay and other materials which they contain, by the gentle action of the waves. The ligament at the hinge in the mean time would decay, until at length, yielding to the pressure of the accumulating matter above the shell, in favourable circumstances, would collapse into its natural closed condition.

The very common occurrence of the valves in juxtaposition, is a striking proof, that during or subsequent to their deposition, they have not been exposed to violent agencies. This becomes even more remarkable in the case of such shells as the *Panopea reflexa*, which almost in every instance is found with the valves properly united. The connexion between the two valves in this shell is the slightest imaginable, after the destruction of the natural organic bond, and an inconsiderable force would have sufficed to separate and break the valves.

The admirable preservation of the shells in many cases is also an interesting fact, and affords another evidence of the absence of all violent agencies at this period. The most fragile species of *Natica*, delicate *Tellinæ*, *Mactra Tellinoides*, the shell and processes

of the *Crepidula*, the minute and sharp angles of the *Fusus Tetricus*, the thin and hollow *Fissurella*—are found in perfect preservation in many places. The state of the shells seems to depend chiefly upon the mechanical texture and chemical character of the materials with which they are mixed, and of which the overlying stratum is composed. In the moist blue clay, the shells are generally found in a very soft condition. In a highly ferruginous clayey bed they are found either partially or entirely dissolved, and beautiful casts remain in their stead.

In many places entire banks occur, composed of *casts* of *Chama* and other shells, sometimes separate, sometimes cemented together so as to form a species of rock. These appearances occur chiefly near the surface, and when the soil is porous and ferruginous. The casts thus formed, often consist chiefly of carbonate of lime, and in many specimens as much as *eighty per cent.* of this substance is found. Casts of this kind belong mostly to the smaller shells, and by far the most common are of the *Chama congregata*. These, as already stated, are often found nearly or quite empty, and we may, therefore, conceive, that as the matter of the shell in an extensive bank of *Chamas* is gradually dissolved, the water charged with carbonate of lime enters the cavities, and slowly deposits the carbonate mixed with fine particles of clay and sand. Thus by degrees the cavities are filled. In the mean time the shell disappears, frequently leaving on the surface of the cast a chalky covering, like the decomposed inner film of shelly matter. In support of this explanation it may be added, that in many casts beautiful crystals of carbonate of lime are found, forming a portion of the cast, and having the appearance of Dog-tooth Spar. In some cases the shelly matter appears to have been dissolved, and its place supplied by the crystallized carbonate, encrusting the earth formerly contained within the shell. Sometimes, too, a thin film of oxide of iron surrounds the cast, showing very distinctly all the markings of the inner surface of the shell. In many localities, presenting a series of beds differing in composition, the shells will be found perfect in some of them, while in others immediately above or below, only casts remain. Thus at the College mill, about one mile from Williamsburg, the upper fossiliferous layer is a yellow silicious sand, containing perfect shells. Below this is a brown ferruginous clay, filled with the most beautiful casts of *Chama*, *Pectunculus*, *Turritella*, &c. The shelly matter has entirely disappeared, and the

casts lie loosely in the cavities produced by the removal of the shells, entirely distinct from each other, and covered by a film of oxide of iron. The layer beneath, consisting of bluish green silicious clay, is full of well preserved *Pectens*, *Pernas*, and a variety of other shells.

In general, the various species of shells are found associated in colonies or groups, but, as in the case of banks of recent shells, these colonies contain many scattered specimens, differing from the general contents of the group. The two species of *Chama*, the *C. congregata* and *C. corticosa*, which are found in almost every deposit of shells in this region, in many cases form extensive beds, with a very small admixture of other genera. The best agricultural marl, of a purely calcareous nature, which is used in lower Virginia, is derived from these beds of *Chama*, the friable texture of the shell upon exposure to the air, rendering this species of marl more easy of application to land, and more prompt in its ameliorating effects. *Crassatellæ* often form an extensive deposit, and the large *Pectens* occur in continuous layers of considerable depth and extent. The different species of *Arca*, *Artemis*, *Crepidula*, &c. present a similar arrangement. Even those shells which are of comparatively rare occurrence, are usually found in little groups. Thus the *Isocardia fraterna* is found, to the extent of a dozen or twenty, closely packed together. This gregarious assemblage of shells of the same species is what would naturally be anticipated in the absence of violent agencies during or after their deposition, and furnishes another very striking proof of the comparatively tranquil condition of the sea or estuary in which they were allowed to accumulate.

DISPOSITION OF THE FOSSILS.

In nearly all the vertical sections of the deposit we are now describing, a series of beds or strata may be observed, each distinguished by the predominance of one or more species, and the order of superposition of these beds frequently continues without interruption for some distance. It does not appear, however, that in localities remote from each other, the arrangement of the shells is always alike, although in many instances there appears to be a striking correspondence. In a majority of cases in the neighbourhood of Williamsburg, the upper layer is composed principally of *Chama congregata*. In many localities also, the large *Pectens*

mingled with *Ostrea Virginica* occupy the highest place. But generally, the same shell re-appears as a predominant constituent of one or more of the subjacent beds; and such is the diversity of arrangement, even in places but a few miles distant, that it is obvious that no general order of succession exists. Thus, in a range of three miles we find *Perna maxillata* in some localities in the lowest stratum of dark blue argillaceous sand; in others, forming an upper, or even the highest layer of the series. At Waller's mill, three miles from Williamsburg, this fossil overlies the other shells; whereas at the College mill, as already stated, it forms a part of the lowest visible stratum.

With the view of conveying more precise ideas of the disposition of the fossils in this region, we annex the following details in relation to some of the more important localities, which have been minutely examined.

King's mill, one of the most interesting fossil localities in the neighbourhood of Williamsburg, is situated on the north bank of James river, about twenty-five miles from its mouth. The cliff in which the shells appear is abrupt, and has a height varying from twenty to forty-five feet above the water. The strata of shells extend along the river with slight interruptions, when the cliff sinks nearly to the level of the water, for a distance of between two and three miles, and they are found in a somewhat similar order of superposition for some distance inland. Their general direction is horizontal, but the outline of any one stratum is frequently very irregular, the surface rising and falling with a steep inclination. This irregular outline is particularly remarkable with the beds of *Chama*, which are very thick at some points, and then fine out rapidly and again expand.

This deposit of shells is covered to the depth of from four to six feet by a brownish yellow sand, intermixed with stripes of clay. Beneath this is a thin layer of about one foot, of very argillaceous and ferruginous clay of a red colour. This rests upon a few inches thickness of gravel, consisting of water-worn quartz, rarely larger than a pea. Beneath this is a layer, from one to two feet thick, consisting of yellow sand, containing a great deal of the green or chloritic sand, arranged in narrow stripes. Next follows a layer of the same sand, containing principally *Chama* and *Venus deformis*. This is from two to three feet in thickness. Immediately below is a stratum consisting almost exclusively of *Chama*, with a few *Arca*

centenaria, &c. This stratum, varying from three to four feet in thickness, is a mass of compacted shells, with but little earthy matter intervening. The earthy matter contains a very large proportion of the chloritic sand. The next stratum is composed chiefly of large *Pectens*, and has a thickness of from one to two feet. Below this is another dense stratum of *Chama*, together with *Arca centenaria*, *Panopea reflexa*, &c., and also very rich in the green sand. Thickness, from four to six feet. Then follows a second layer containing *Pectens* with *Ostrea compressirostra*, one foot in thickness. A third stratum in which *Chama* predominates, follows next, in thickness from two to three feet, and at the base of the cliff is a layer containing *Pectens*, *Ostrea compressirostra*, &c. from four to five feet in thickness.

Thus through a height of more than twenty feet in some places, the cliff consists principally of shells, of which there are a great many species, besides those mentioned as predominating in the several beds. On the extensive contiguous estates of King's mill and Littletown, these shells are largely used as a manure: and for this purpose the first and second beds of *Chama* are preferred on account of the immense amount of calcareous matter, and the large proportion of green sand which they contain. Judging from the occasional appearance of bluish green clay on the line of the beach, and in some places immediately at the base of the cliff just described, it is highly probable that a continuous stratum of this substance lies beneath the other beds throughout the whole extent observed. A horizontal bed of yellowish clay extends for some distance along a lower portion of the cliff, in which there are no fossils; running within a few feet of its upper edge, and beneath this bed, and parallel to it, is a thin layer of the iron ore formerly described. At the foot of this cliff appears the underlying stratum of clay.

DESCRIPTION OF THE CLIFFS AT YORKTOWN ON YORK RIVER.

The elevation, abrupt form, and peculiar construction of the cliffs at this point, and for some distance, both above and below, render it an interesting spot to the geologist. A dry and ample beach, uninterrupted by creeks or inlets for several miles, affords a ready access to the banks, while the river's edge, strewn with fossils which have fallen from the cliff, exposes a considerable variety of

interesting specimens. Immediately at York, the river is only three-eighths of a mile in width, but both above and below it expands to a breadth six or seven times as great.

At Wormley's creek, about two miles below the town, the cliff about to be described begins ; but from this point, down to the extremity of the peninsula, the banks are uniformly flat and low. The cliff here consists at bottom of a bluish sandy clay, containing immense numbers of *Turritella alticosta*, *Cytherea sayana*, and many small Univalves, over which lies a layer of brownish yellow sand, with very few shells, and those chiefly *Nucula limatula*, and a few other species. To this succeeds a stratum composed almost entirely of *Crepidula costata*, so closely packed together, as to leave little space for sand or other earthy matter. The whole is covered to a variable depth by a stratum of coarse sand of various strong tints, and evidently highly ferruginous. The elevation of the cliff increases, and the nature of its contents gradually changes in approaching York. The lower stratum disappears entirely after continuing for something less than half a mile, previous to which, however, its fossil contents are changed; the layer of the *Turritellæ* being replaced by *Crepidula* closely packed together. *Crepidula* still runs on horizontally above, and the intermediate stratum is now densely filled with *Pectens*, *Venus deformis*, *Ostrea*, and a great variety of small shells frequently connected together, so as to form hard masses of considerable size. Still higher up the river the deposit assumes the character of successive layers composed of comminuted shells, connected together so as to form a porous rock. These fragments are generally so small and so much rubbed and water-worn, as to render it impossible to ascertain the species of shells of which they once were portions. Many small shells, and occasionally large ones, particularly *Pectens*, are found mingled with the other constituents of the rocks ; and in some places thin layers of shells, such as *Venus* and *Crepidula*, intervene between the adjacent strata. The height of this fragmentary rock amounts in some places to forty feet. In most places it has a highly ferruginous aspect, though this is not invariably the case. Frequently shells of considerable size, such as *Lucina anodonta*, are seen coated with, or entirely changed into, crystalline carbonate of lime, firmly cemented in the mass. The texture of the rock is various, at some points admitting of being readily excavated by the pick and spade, so as to form caves which have been occasionally used by the in-

habitants; in other places exhibiting a hard and semi-crystalline structure, and having the compactness of some forms of secondary limestone. The lower portion of the cliff, having less cohesion than the rest, has been scooped out by the action of water, so as to give it occasionally an impending attitude.

Above the town, the stratum of fragmentary rock becomes much thinner, being now reduced to about ten or twelve feet. A stratum of yellowish argillaceous clay, abounding in *Artemis acetabulum*, *Mastras*, and other large shells, lies immediately beneath the rock; and lower still, appears the stratum of bluish clay, filled with *Nucula Limatula*, several species of *Fusus*, and various other fossils.

A narrow layer of *iron ore* extends along the cliff, with occasional interruptions, at a small distance above the fossiliferous strata.

This fragmentary rock continues in a narrow band, with some interruptions, for about a mile and a half above York. Beyond this point it is met with chiefly in detached masses. Extensive beds of shells, similar to those which appear at York, come to view in the vicinity of Bellefield, and line the shore for a distance of about three miles. These beds rest on the usual stratum of sandy clay, and are in some places, as already described, covered by a stratum of the same substance. At a still remoter point, about six miles above York, on Jones' plantation, a porous rocky mass occurs, overlying the stratum of shells in a thin and interrupted layer. Though very similar in appearance to the fragmentary mass before described, and evidently at one time composed of portions of shells, it is almost devoid of any trace of carbonate of lime. It appears to consist of silex, slightly tinged with oxide of iron; approaching in its porous character and harsh gritty texture, to the nature of the burr stone of France. Associated with this, is a more compact rock, containing some carbonate of lime, with much silex, and exhibiting very perfect casts and impressions of *Pectens*, *Cardium*, &c. Over these strata is the usual layer of ironstone, and the general aspect of the upper beds is somewhat ferruginous.

It is interesting to remark, that with some interruptions, a fragmentary deposit, similar to that observed at York, extends to the lower extremity of the peninsula. At Pocosin, a flat swampy country, which is often inundated by the tides, this deposit is uniformly met with by digging a few feet below the surface. *Pectunculus*, *Pecten*, *Ostrea*, as well as numerous small shells, occur

mingled with it, as at York; the fragments, however, are not cemented together but form a loose friable mass. A rock, consisting of cemented fragments of shells, occurs also at various other points on the eastern portion of the Miocene district; and a fragmentary deposit, like that above described, is found near the extremity of all the peninsulas formed by our great rivers.

A very interesting feature in the structure of the cliff at York remains to be described. Though the general direction of the fossil beds is nearly horizontal, several of the strata of rock are composed of transverse layers parallel to each other, generally dipping towards the north, and making an angle of fifteen or twenty degrees with the horizon. The course of these laminæ sometimes differs in adjoining strata, and in some places the obliquity diminishes gradually until the laminæ become horizontal; thus presenting a remarkable resemblance to the appearances described by Lyell and others, as existing in the Crag of England. The phenomenon here described, viewed in connexion with the fragmentary structure of the rock, and the general distribution of broken shells over the lower extremity of the peninsula, would seem to indicate the former agency in this district of coast currents and an ocean surf. The beds of shelly matter comminuted by these means, and subsequently elevated above the level of the tide, would be gradually cemented into a rocky mass by the crystallization between the particles of such portions of the calcareous matter, as the rain when just fallen was capable of dissolving. The solvent power of rain, being chiefly due to a portion of carbonic acid with which it becomes united in its descent through the air, would be lost, as the liquid percolated through the shelly strata, and thus the calcareous matter which it had seized, would be gradually deposited in the crystalline form.

Besides shells and Zoophytes, the bones of cetaceous animals and the teeth of sharks, are of very frequent occurrence in the fossiliferous beds, but no remains of *fresh water or land animals* have as yet been discovered. The total number of species of shells from these points which have yet been identified, is about ninety-six, to which may now be added several new species recently discovered,⁷ and described in a joint paper by Professor H. D. Rogers and myself.

The structure of the interesting portion of the state lying on the eastern side of the Chesapeake is, so far as hitherto explored, extremely simple; but as yet only the surface strata have been

examined, and it is far from being improbable, that at no very considerable depth beyond that reached by the ordinary wells of the country, deposits calculated to prove of much economical value, might be attained. Beneath the superficial sands and sandy clays of the country, a bed of clay of a tenacious character is first reached, frequently impregnated with salt, and communicating to the water obtained from it more or less of a brackish flavour. Beneath this a more arenaceous bed occurs, beyond which, as far as I can learn, no digging has been carried. From this more sandy stratum, water of a purer quality is procured. Hitherto no beds of marl or fossil shells have been found anywhere in this region. Yet there is reason for the opinion, that such deposits would be met with by boring to some depth, and possibly near enough to the surface to prove available in the agriculture of the country.

The water of the Miocene marl district, whether of wells or springs, presents nearly as great variety as the mineral beds from which it issues. In the more eastern parts of the region, it generally contains a notable impregnation of common salt, and in neighbourhoods where shell marl abounds, a marked proportion of calcareous matter. The copiousness and transparency of springs of the latter description, as well as the carbonate of lime which they hold dissolved, give them a character nearly allied to that of the *limestone springs* of other regions, while the common salt which they almost invariably contain, and with which they are sometimes strongly imbued, constitutes an important feature of distinction. The beds of ferruginous clay and sand in many cases, impress a slight chalybeate character upon the water, and occasionally impart to it so large an impregnation of iron as to render it of decidedly medicinal utility.

Owing to the calcareous matter, and occasionally other substances which it holds in solution, nearly all the water of this region possesses the character of *hardness*. By *boiling*, this evil is entirely remedied;—the carbonate of lime is precipitated, first rendering the liquid cloudy, and subsequently collecting on the sides and bottom of the vessel in the form of a thin incrustation. In such of the arts as require a water free from this peculiarity, the marl water should be boiled previous to use; or, in lieu of this, though by no means an effectual substitute, it should be exposed for some time to the sun in open reservoirs. The carb. acid which is the chief solvent of the calcareous matter, being expelled by heat, suffers the latter to separate

from the liquid, and thus the cause of the hardness of the water is in a great degree removed. It is obvious from these facts, that the water obtained from strata of gravel, sand or pure clay, will in general be purest and most suitable for employment in the arts. As an example of the kind of impregnation usual in the water of this district, I subjoin the results of an analysis of the contents of a spring in James City county, near Williamsburg. In 400 cubic inches of this water, the aggregate of solid matter was found to be 104.49 grs. consisting of the following substances, viz :

Muriate of soda,	49.84
Muriate of lime,	15.08
Carbonate of lime,	26.73
Sulphate of lime,	6.24
Silica and alumina,	4.00
Sulphate of soda,	0.25
Ammonia,	<i>a trace.</i>
Organic matter,	1.00
Loss,	1.75

104.49

The large proportion of Muri. soda shown to be present in the above instance, is an interesting fact, particularly when taken in connexion with the locality whence the water was procured. For, it cannot be considered probable that this ingredient could be derived from the neighbouring rivers or the bay, as this would imply an extent of filtration in a horizontal and upward direction, which it would be unphilosophical to admit. It is rather, as I conceive, to be looked upon as referable to the former impregnation of saline matter derived from the waters of the ocean, beneath which nearly all the strata of this region were originally deposited.

NATURE AND VARIETIES OF THE MIOCENE SHELL MARL.

In the general description of the district of which we are now treating, a detailed account has been given of the arrangement of the beds of fossils as they occur in nearly all the localities which have been examined, accompanied by an enumeration of the principal shells, an account of the materials in which they are embedded, and with which they are associated in contiguous strata. We are next to consider the materials of these beds in relation to their agricultural importance, and to exhibit the relative value of the marl of

different localities as illustrated by chemical examination. A large proportion of the matter of all shells consists of *carbonate of lime*. Hence they are nearly identical in composition with limestone, chalk and marble. To this ingredient, in whatever form it may be applied to the soil, general experience has ascribed a very high degree of fertilizing power, and hence, in the application of all the varieties of calcareous marl, we are guided chiefly by the proportion of the carbonate which they contain, as determined by chemical analysis. It should not, however, be inferred, that the various mixtures of earths and other substances with which the calcareous matter is usually associated, are devoid of useful action when applied to land. The experience of agriculturists is certainly inconsistent with such an opinion, though it has most clearly evinced the powerful efficacy of calcareous manures. The invaluable publications of the editor of the *Farmer's Register* by directing the attention of farmers to the employment of the shell marl with which nature has supplied them in such rich abundance, have led so extensively to the application of this manure, and have produced so general a conviction of its fertilizing effects as to render it unnecessary in this place to introduce either facts or arguments in its favour. To the valuable practical suggestions of this gentleman, contained in the "calcareous manures" and other publications, we are indebted for much of the amelioration which has taken place in the agriculture of eastern Virginia, and I therefore cannot do better, in alluding to this branch of my subject, than to recommend these works to the earnest perusal of all who are interested in advancing the prosperity of that portion of the state.

But although the richness of the marl is mainly dependent on the *proportion* of its calcareous contents, it is also largely influenced by the *nature* and *condition* of the shells of which it is composed. It is well known that the recent oyster shell, especially in its unbroken state, is far less immediate and powerful in its action upon land than the friable and pulverulent shells, of which many of the most valuable marl beds are principally made up. Yet in the composition of the recent oyster shell, the amount of calcareous ingredient is nearly as great as in the richest marl beds which we have examined. According to an analysis which I made some years ago, 100 grains of this material were found to contain :

Carbonate of lime,	95.18 grs.
Phosphate of lime,	1.88
Silex (probably accidental,)	0.40
Water,	1.62
Insoluble animal matter,	0.45
Loss, &c.	0.45

100.00

[*Vide Farmer's Register, Vol. 1, and Silliman's Journal.*]

These remarks being also applicable to some species of fossil shells, it becomes necessary to a judicious selection of the marl, to give some attention to the different nature of the shells contained in the several varieties of marls offered to our choice.

KINDS OF SHELLS WHICH ARE LEAST LIKELY TO BE USEFUL.

The Fossil oyster and Scallop shells, (*Ostrea Virginica* and *Pecten*,) of which many marl beds are almost exclusively composed, are generally found in a nearly unaltered state. Comparing the composition of these shells, as ascertained by my analysis, with that of the recent shells, the *animal* matter which, though small in quantity, seems to act powerfully as a cement for the other materials, was found to have been retained in almost undiminished proportion; and thus these shells are scarcely better fitted for the soil, than recent ones of the same species. It is to the animal matter retained by the fossil scallops that we are to ascribe the dark colour which they assume when burnt for lime. Whatever might be the usefulness of this ingredient if mingled with the soil, it here operates to impair the value of the shell as calcareous manure by the insoluble character it imparts to the materials it holds together. Next in tardiness of disintegration, and in consequent inefficacy as a manure, may be enumerated the large clam, (*Venus mercenaria*), and an oblong smooth flat shell, (*Crassatella*.) These, however, have evidently undergone a change, which prepares them for yielding, more readily than the former, to the agencies of the seasons. Most of the other species, though entire when first found, soon fall to pieces and spread their fertilizing fragments through the soil. There is, however, even among them some room for choice—and this leads us to consider the

KINDS OF SHELLS WHICH ARE MOST SUITED FOR THE PURPOSE OF MARLING.

The Chama, formerly mentioned as occurring in extensive beds in some portions of the Miocene, and existing in considerable proportion in nearly all the fossil strata, forms the principal component of some of the most productive marls. This is a small two-valved shell of rugged exterior, which readily breaks to pieces in the ground, and is spread evenly over the land with great facility. Another shell, (*Serpula*,) of which there are numerous rich beds in Surry county, possesses these advantages in a still higher degree. From its fragile texture, and irregular tubular structure, it is quickly mingled with the soil in a minutely subdivided state, and as like the Chama, it frequently occupies the marl beds to the exclusion of other fossils, it furnishes a marl of a very superior description. As a general rule, the small shells are most likely to prove efficacious, as well from the fact that, where they occur, the proportion of carbonate of lime and green sand is usually great, as because they are most easily reduced to the condition in which they become available in the land.

Of the Pulverulent white marl.—In many situations the marl presents an appearance not very unlike that of an impure chalk. The mass of the stratum is chiefly made up of a white or yellowish friable material, intermixed with fragments of the harder species of shells. In such cases the shells are rarely found entire, and the condition of the fragments is usually such as to render it difficult to recognise the species of fossil to which they belonged. Many extensive beds of marl of this description have been opened in the counties of Middlesex, New Kent, James City, York and Gloucester, all of them largely abounding in calcareous matter. Even as much as 97 per cent. of this substance was found in a specimen from one of these localities; and it will appear from the table of calcareous marls hereafter to be given, that in general the proportion exceeds 80 in the 100. Occasionally, however, a mixture occurs in which the calcareous matter is blended with a large proportion of white clay and sand, presenting in the mass an aspect so nearly resembling the former, that without chemical analysis it would be difficult to distinguish between them.

Of the Blue marl.—In our general description of the arrangement of the fossiliferous strata, mention has been made of the bluish green or clayey marl which occurs low down in the ravines and near the water's edge on the river banks. This is what is usually known

amongst farmers as the blue marl. From the soft condition of the shelly matter which it contains, and the predominance of clay in its composition, this has been found peculiarly serviceable when applied to the more arenaceous varieties of soil. In the quantity of calcareous matter which it contains, it is usually inferior to the beds of a white or brown colour, which in many places rest above it, though it is not to be inferred that in many instances it may not prove equally advantageous to the land. The colouring matter of the clay appears in part to consist of a carbonaceous matter, derived probably from the organic materials originally associated with the shells, and often in part of a minutely divided greensand, either of which ingredients might be expected to aid the calcareous and clayey matter in benefiting the soil.

Of the hard Ferruginous Marl.—In some localities the beds consist of shells more or less broken, intermixed with a brown ferruginous sandy clay, and often cemented with these materials into masses which are broken with some difficulty. These, although rich in calcareous matter, must obviously, from their mechanical texture, prove less valuable than either of the former. To this class, also, may be referred the shell rock, and fragmentary masses approaching to limestone, which occur in various places.

From the large per centage of carbonate of lime, which these contain, there can be no doubt that, by burning, they might be converted into a highly valuable lime. A specimen from the cliff at York, yielded eighty-seven per cent. of calcareous carbonate, as large a proportion as most of the valley limestone have been found to contain: computing the quantity of caustic lime, corresponding to this, we find that one hundred pounds of the shell rock would yield 48.7 pounds of strong lime. It is, therefore, well worthy of consideration, whether the conversion of this material into lime, might not be an object of profitable enterprise. In the neighbourhood of York and other places, where it occurs, rock of sufficient hardness might be obtained in great abundance and at comparatively little cost; and the cheapness of fuel would render the operation of burning, one of moderate expense. That much of this rock, when exposed to intense heat, would fall to pieces, and thus injure the value of the product for distant use, is undoubtedly true. But there is also much of it found in bands throughout the cliff, which has almost as great solidity and permanency in the fire, as a secondary limestone, and from this, a lime of superior character might unquestionably be

produced. Owing to the great abundance of shell marl in these places, and the general resemblance of this material to the constituents of a marl bank, its probable utility in this point of view, appears hitherto to have been overlooked. But regarding it in its true light, as a *tertiary limestone*, we see no reason why it should not become a source of profitable manufacture in its immediate vicinity.

OF THE GREENSAND, SULPHATE OF IRON, SULPHUR, AND OTHER MATTERS
ASSOCIATED WITH THE MARL BEDS.

Greensand.—As already intimated, this substance is frequently found disseminated in the marl, and also in the overlying stratum of clay or sand. From the remarkable effects of comparatively small quantities of this material when applied to land, there can be no doubt that many of the marls of lower Virginia owe some of their value to its presence. Supposing only as much as ten per cent. of this substance in a marl, and this is far below the amount which I have ascertained to exist in many localities, one hundred loads of marl would correspond to ten of the greensand, an amount which in New Jersey has often been found productive of striking benefit. Several of the most efficient marls which I have examined, were more remarkable for the large proportion of this substance contained in them than for their richness in calcareous matter. In many marl pits which I have visited, the impressions of the pick and spade were streaked with green marks, which upon inspection were found to result from the bruised granules of this matter. In such cases, there can be no doubt of the existence in the marl of an amount of greensand capable of affording material aid to the growing vegetable. In the layer immediately above the marl, also, it sometimes exists in considerable quantity—and hence instead of rejecting this overlying mass, in many cases it would be decidedly better to carry it out upon the land along with the calcareous matter. The experience of many farmers has already shown the propriety of this plan, and some even entertain the opinion that this upper layer, where the greensand abounds, is quite as beneficial as the marl itself. Further observations respecting the greensand will be given in treating of the Eocene marls, of which it constitutes a very important ingredient.

Sulphate of Iron and Sulphur.—In some parts of the Miocene district, there occur beds of clay more or less sandy, and usually of a dark colour, containing these substances in a minute but still ap-

preciable quantity. Such matter, there is reason to believe, would not in general prove directly beneficial to the soil. The former has been thought positively detrimental to vegetation, and certainly when applied in considerable quantity, this is its effect. What agency it might exert in a more diluted state, and mingled with other matter, we are without the means of determining. Probably under such circumstances it might operate as a stimulant, and thus contribute to the growth. The same doubts are also applicable to the other substance above named. Yet in some well authenticated cases, the action of these *copperas and sulphur* clays has been found strikingly beneficial. In these instances, however, it would seem that much if not all the benefit was produced by the effectual protection which even minute quantities of these substances, especially the latter, afford against the attacks of insects. In a cotton field in which all the alternate rows were lightly sprinkled with earth of this description, the plants so treated grew up vigorous and healthy, while the others became sickly and were nearly devoured by insects. Much careful observation is required to determine the kind and mode of influence which these substances exert, and it would be premature, in our present ignorance of the matter, to assert any convictions on the subject. The presence of the former of these ingredients, if not recognised by the copperas flavour, will be readily discovered by steeping the earth in water, decanting the clear liquid, boiling it down to a small volume, and then adding tincture of galls or prussiate of potash. A black or brown colour with the former, or a blue one with the latter, would indicate its presence. The experiment, however, should be made in a glass or china vessel. The sulphur becomes manifest to the smell when the clay is heated, and even at ordinary temperatures its peculiar odour may often be perceived.

The following table exhibits the per centage of carbonate of lime in a number of the Miocene marls which I have examined. The analysis were made with the "apparatus for analysing calcareous marls and other carbonates," described in *The Farmer's Register and Journal of Science*. No attempt was made to ascertain the proportions of sand, clay or greensand, because the trouble of the analysis would have been increased more than ten fold, and probably no *useful* result could have been attained. In each experiment the appearance and character of the undissolved matter was noted, and thus a general estimate formed of the other ingredients of the speci-

men. These notes are contained in the fourth column, the first giving the localities, the second the aspect, and the third the quantity of calcareous matter.

TABLE, exhibiting the per cent. of Carbonate of Lime in
Miocene Marls.

<i>GLOUCESTER.</i>			
Walter Jones,	White sandy marl, with fragments of Perna, . . .	37.1	The residuary matter chiefly silex—No greensand.
Walter Jones,	White clayey marl, . . .	61.5	The residuary matter chiefly clay, with a little g. sand.
T. W. Fauntleroy,	White pulverulent, . . .	60.0	Chiefly clay—No g. sand.
T. W. Fauntleroy—several feet below surface,	Fine chalky—few traces of shells,	96.8	No g. sand.
Do.—from same bed near the surface,	More arenaceous, . . .	61.8	Sand.
Dr. Taliaferro—from gray low grounds,		40.0	
Do.—black low grounds,		68.1	
Do.—highlands, upper stratum,		57.2	
Do.—highlands, lower level,		35.9	A little g. sand.
<i>ISLE OF WIGHT.</i>			
Burwell's bay,	Blue marl,	62.0	A little g. s.—chiefly clay.
Ditto,	Yellow marl,	55.2	Sand, clay, and a considerable proportion of Peroxide of iron.
Joel Holleman,	White, with small shells, . . .	80.2	A little g. sand.
<i>JAMES CITY.</i>			
The Grove—Burwell's,	Reddish gray, with fragments of shells and numerous specks of g. sand, . . .	60.2	Sand, clay, and large proportion of g. sand.
Do.—from a lower stratum,	Similar appearance—specks more numerous, . . .	54.7	Do. do.—still more g. sand.
King's mill cliff,	Similar aspect,	62.0	Do. do.—much g. sand.
Judge Semple's farm, two miles below Williamsburg,	Similar aspect,	79.0	Do. do. do.
Dickie Galt's, near Williamsburg hospital,	Pulverulent and white, . . .	79.0	No g. sand.
Dr. Semple, thirteen miles from Williamsburg,	Yellowish pulverulent, . . .	84.3	Sand and clay.
Do. do.—another stratum,	Grayish yellow,	54.5	Do. do.—and some g. sand.
Dr. Peachy's, near Jamestown,	White pulverulent,	71.0	Chiefly clay.
Mr. Wynn's, near York,	Do. do.	72.7	Clay, and a little g. sand.
Mr. Wade's,	Do. do.	69.1	Do. do.
<i>LANCASTER.</i>			
Curratomen—J. Cabell, Esq.—1st bed,	Grayish yellow—silicious clay filled with hollow casts of Astarte Undulata, . . .	48.8	Clay, sand, and ox. iron—No g. sand.
Do. do.—2d bed,	Fragments of shells, but no casts,	54.6	Do.
Do. do.—3d bed,	Do. do.	57.4	Do.
Do. do.—4th bed,	Do. do.	52.7	Do.
Do. do.—5th bed,	Do. do.	38.4	Do.

<i>MIDDLESEX.</i>			
Mr. Jesse's, near Urbanna—			
No. 1,	White pulverulent,	92.3	Chiefly clay.
Do.—No. 2,	Sandy and greenish blue, .	33.0	Much g. sand.
Dr. R. Christian, near Urbanna,	Chalky—small fragments of		
Urbanna,	shells,	59.5	Sand and clay.
Mrs. Thruston's, 8 miles from			
Urbanna,	White and pulverulent, . .	95.4	
<i>NEW KENT.</i>			
Mr. B. Crump, five miles below			
court-house,	White pulverulent,	93.6	
Mr. Ro. Christian's,	Do. do.	76.1	
Mr. J. Marshall,	Do. do.	85.0	
<i>PRINCE GEORGE.</i>			
Mr. Wm. Harrison,	Do. do.	72.7	
<i>SURRY.</i>			
Mr. C. Jones,	Grayish,	28.3	Sand and clay, and much g. sand.
Mr. C. Jones—lower stratum,	Grayish yellow,	43.2	Sand, clay, ox. iron, and much g. sand.
Do.—upper stratum,	Abounding in Chama, . . .	62.7	Do.—much g. sand.
Capt. Smith, court-house, .	Bank made up of Chama and		
	Serpula,	72.9	Much g. sand.
Bacon's Castle,	White pulverulent,	97.7	No g. sand.
Mr. D. Stith, court-house, .	White sand, with fragments		
	of Perna,	35	Sand—no g. sand.
Union Hall,	Very argillaceous,	29.8	No g. sand.
<i>YORK.</i>			
Mr. R. Garrett's, three miles			
below York,	White pulverulent,	90.2	
Belle farm—Major T. Griffin,	Reddish yellow—fragments of		
	shells,	79.2	Clay and ox. iron.
York cliff,	Rocky and subcrystalline,	87.3	Do. do.

EOCENE MARL DISTRICT.

As already indicated, the extent and boundaries of this interesting portion of eastern Virginia are as yet in a great degree matters of conjecture. The discovery of an Eocene deposit in the state first announced by me about eighteen months ago, in a communication to the Farmer's Register, has been followed up by a minute personal examination of some parts of the district in which it occurs, more especially on the James river and Pamunkey. Its existence on the Rappahannock and Potomac has also been ascertained, and specimens have been obtained from a number of intermediate points. With regard to the region South of the James river, though facts have been procured which show conclusively that the deposit continues to the southern boundaries of the state, time has not admitted of such an investigation as would be necessary in defining its extent. A regularly continuing line of observations on the

Pamunkey river, commencing below the point at which the deposit appears above the water's edge, and extending up the river to the junction of the North and South Anna, where it terminates, has served to develop the arrangement and composition of the strata, and to determine the width of this portion of the formation. An inspection of the most important Eocene localities on the James river has also contributed many interesting and valuable facts, while on the Rappahannock and Potomac, its western limits have been determined with as much accuracy as could be attained by transient observations directed only to a few localities.

Wherever observed, the arrangement of the beds of the Eocene and the minerals and fossils contained in them, have been found strikingly alike, and hence the description of any transverse line of the formation may be regarded as conveying a just representation of its character throughout. At the same time, however, it is by no means to be assumed, that in all localities the same arrangement or composition of the strata must necessarily exist; for within a short distance in observations already made, considerable diversities have been observed to exist. But there can be little doubt that the general order of the strata already remarked, as well as the character of the fossils which they contain, will present much uniformity whenever the formation may be discovered within the limits of the state.

The existence of Miocene strata over the Eocene, has been referred to under a former head, and some account of this more recent overlying deposit within the district of which we are now treating, may, with propriety, be prefixed to the description of the Eocene itself.

OF THE MIOCENE WHICH OVERLIES THE EOCENE.

Westward of the limits of the Miocene previously defined, the general level of the country continues gradually to rise. A surface more generally undulating, and strewn with water-worn fragments of stone, sometimes of considerable size, marks our approach to the region of hills and rocks, whence these memorials of the destructive forces of a former period have been derived. The superficial strata in the western portion of this district is generally a coarse sand or gravel, often containing large masses of rounded sandstone and other rocks, of which the parent strata are gene-

rally to be found at no remote distance to the northwest. An inspection of these pebbles is sufficient to show, that in many, if not nearly all cases, they are derived from the grits and sandstones with which the bituminous coal of eastern Virginia is associated, while from the similar nature of the sand and gravel in which they are embedded, we are entitled to conclude, that at least in part, they also refer themselves to the same region for their origin. In the hills at and below Richmond, and in many other places these beds of gravel have considerable depth, and present a structure at once curious and instructive. A series of strata at these places, in some of which the pebbles are disposed in horizontal lines; in others, in lines oblique, but still generally parallel, inclining downwards to various points in the different layers, give striking evidence of the agency of those diluvial and oceanic currents, of which geologists have discovered so many memorials in other regions, and may serve when minutely studied, to throw much light on the physical changes to which this portion of the continent must formerly have been subjected.

Beneath these beds of gravel, in many places strata of clay occur; but whether referable to the same epoch of deposition, cannot as yet be clearly ascertained. Many beds of very argillaceous clay, suited for the potter and brickmaker, and occasional layers of a pure beautiful yellow ochre, may be placed in this portion of the series.

Other strata of clay and sand of a peculiar character present themselves in many localities beneath the superficial beds. These contain a record of their origin legible to the geologist, in the impressions of shells and Zoophytes with which they are generally filled. On comparing these casts, which in most cases can be easily recognised even in their more delicate markings, with the fossils of our Miocene marl strata, their identity is established, and thus the strata in question at once take their places in the series of Miocene Tertiary deposits. In many parts of Hanover, King William, Henrico, and other counties in this range, these beds of clay are found, usually characterised by a dark greenish gray or brown colour, a sulphureous odour, and an astringent taste. On Governor's hill in Richmond, a stratum of the same kind is exposed; and at this spot, the fossil impressions and other characters above noticed, may be distinctly seen. Like the clays and sands formerly described as associated with the Miocene, these contain sul-

phate of iron (or copperas,) sulphate of alumina (or alum,) and sulphur in an uncombined condition. So large a proportion of these substances is sometimes present, as to render the water obtained from the strata in which they exist, absolutely unfit for use.

It is to the existence of these materials in the strata, that we are to look for the cause of the disappearance of the calcareous matter, in the form of shells, which they once evidently contained. Either of the sulphates above named would exert a rapid decomposing action on the carbonate of lime, of which shells principally consist. The sulphuric acid of the sulphate combining with the lime of the carbonate, thus converting it into gypsum, while the carbonic acid would, in great part, escape in the form of gas. That the gypsum is not now discovered in these beds, is an obvious result of the comparative solubility of that substance in water; its continuance in the strata being only possible where a heavy covering of clay excluded the percolating liquid.

Useless, if not injurious, as these clays are now believed to be when applied to land, there is reason to think that they are capable, by a little application of chemical knowledge, of being rendered truly valuable as an auxiliary manure. The gypsum into which their enclosed shells were once converted, would doubtless have imparted to them a high agricultural value. Can we not replace, if not all, some portion of this fertilizing material, by mingling the clay with the more pulverulent shell marls occasionally found in its vicinity? That this mixture would result in the conversion of a portion of the shelly matter into gypsum, there can be no doubt; and where the clay was originally rich in copperas and alum, the amount of the gypsum thus compounded would be proportionally great. Experiments on this subject are well worthy of being tried, not only with the clays here mentioned, but with those of a similar nature, which, as already remarked, occur in the more eastern portion of the Tertiary districts of the state.

Before the *amount* of *gypsum* to be anticipated from such a treatment of these materials can be estimated, a chemical determination of the proportion of sulphates of iron and alumina must be had, and to this point future analysis might be usefully directed.

But though much of the Miocene marl in this district has been exposed to the destructive chemical agencies above explained, much

also is found retaining its carbonate of lime in undiminished quantity.

On the lower levels on the river banks, it appears seldom to have escaped the dissolving and decomposing action of the sulphates, while in the highlands it may usually be found containing its calcareous matter nearly as when first deposited. In King William, Hanover, Prince George, &c., beds are found in the highlands, at some distance from the rivers. The fossils they contain are identical with those of the marl beds farther east, and the materials with which they are intermixed present no peculiarity important to be remarked. Specimens of this Miocene from Hanover, King William and Prince George, exhibit a good per centage of the carbonate of lime, and as might be expected, the strata from which they were taken are usefully resorted to by the neighbouring farmers.

As would be inferred from remarks previously made, the general level at which this marl occurs, is higher than that of the Eocene, and here the promise is held out that this latter, even in the highlands, would be exposed by excavations carried to some depth beneath the lower limits of the former.

In examining the Eocene deposit on the Pamunkey and James rivers, the interesting geological fact was observed of an *actual superposition* of the Miocene upon it; and on the Pamunkey, the precise point was determined at which the Eocene first makes its appearance above the water-line, being there overlaid by a heavy bed of the more recent deposit. This occurs at Northbury, and directly opposite at the plantation of doctor Charles Braxton.

OF THE EOCENE OR LOWER TERTIARY MARL.

The descriptions and facts which will be comprised under this head, will principally refer to the localities on the Pamunkey and James rivers, to which especial observation has been directed. At the same time that their value, as applying to the Eocene district generally, may be regarded as being sufficiently established by general geological analogies, as well as such observations upon other portions of the region, as the present early stage of the inquiries has allowed me an opportunity of making. No region of eastern Virginia holds out more certain promise of reward to future investigation, and none will reap from the research more lasting and important benefits.

DESCRIPTION OF THE EOCENE STRATA OF THE PAMUNKEY.

Rising above the water-line at Northbury, the upper surface of the deposit is seen ascending with a very gentle slope, as it extends higher up the river, until at Newcastle it attains an elevation of about 25 feet above medium tide. Beyond this point, with slight undulations in its outline, it continues with but little general deviation of height from the water-line to near its termination at the junction of the North and South Anna, where it dips or thins out until lost immediately on the verge of the coarse sandstone, which there, for the first time, makes its appearance in massy form. The deposit appears on both sides of the river, wherever the flats do not intervene, and at the base of the second level, corresponding in position to its place in the river cliffs in the same vicinity.

On the south side of the river, the deposit has been particularly examined, at Northbury, Hampstead, Retreat, Washington Basset's, Walker Tomlin's, Mrs. Ruffin's, Mr. Roane's and Mr. Wickham's, where it terminates. Specimens have been collected from other localities, either on the river or at the base of the second level: on the north side, at Chericoke, captain Hill's, Mr. Nixon's, Piping Tree, Newcastle, Dr. Braxton's and Mr. Fox's. Specimens also from various other points on, and remote from the river, have been procured, and thus a somewhat minute acquaintance with this portion of the Eocene tract has been attained. Towards the southern boundary of the deposit, the following arrangement of strata occurs, commencing at the top.

1st. A stratum of greenish yellow earth containing no shells, but numerous traces or casts of them, plainly showing that shells were at one time embedded in the mass. Sulphate of lime or gypsum occurs in crystals sometimes of considerable size, interspersed throughout this stratum, which is principally made up of coarse silicious sand, blended with granules of greensand or silicate of iron. The thickness of this bed is variable; at Chericoke and Hampstead it is about two feet; at Retreat from four to five.

2d. Beneath this lies a layer of dark greenish blue or brown earth, which when dried, generally falls to pieces, and is discovered to consist mainly of coarse silicious sand, and greensand, together with shells generally in a broken condition. The shelly matter is sometimes entirely wanting, though occasionally it composes a large por-

tion of the mass. At Hampstead, the calcareous ingredient exists in large proportion and in a finely divided state. Frequently, one or more thin layers of the oyster shell peculiar to the lower tertiary region occurs in the body of this stratum; a fact remarkably exemplified at Piping Tree, and for nearly a mile further down the river, where the layer of shells forms a hard rocky shelf laid bare at low tide, and presenting large and perfect specimens of the fossil oyster, in the midst of the greenish stratum just described.

At Chericoke the stratum rises to about four feet above the water, and as ascertained by digging, descends to seven feet below the river shore.

Higher up the stream, these strata attain a greater elevation, and subjacent beds, not apparent at either of the points above described, come gradually into view. In these localities we usually find,

1st. A layer of dark grayish-green or grayish-brown colour, containing multitudes of shells, generally in a perfect state; the fossil oyster shell already referred to abounding chiefly in the upper part of the stratum. Beneath this, but frequently separated by no distinct line of demarkation, we find,

2d. A layer of darker hue, containing less shelly matter, and the shells chiefly of the smaller kinds; and

3d. A stratum of the same appearance, in which no calcareous matter can be discovered.

All these strata contain a large portion of the greensand. In the upper and lighter-coloured beds, the granules of this substance are very obvious to inspection, resembling in size and colour the grains of gunpowder, and giving when bruised a bright green stain. In the lower beds they are more minute, and being intimately mingled with the other materials present, are not readily recognised, excepting by the general greenish character of the mass. These beds also contain a great deal of Mica in fine sparkling scales. Of the depth of these strata below the level of the river nothing definite is known, no extensive excavations having yet been made. At Mr. Wickham's they are found to rest upon a layer of large pebbles, but this basis is perhaps not co-extensive with the deposit lower down the river.

When the upper bounding surface of the Eocene is even and uniform, it is always marked by a *thin layer of black pebbles*, upon which there usually rests a bed of olive-coloured earth, or of friable

white clay—and in some cases, both these strata, the olive-coloured being next the Eocene.

This olive earth is of a fine texture, containing but little gritty sand. Here and there a shark's tooth in a decomposed condition, or the impression of a shell may be discerned. The white stratum abounds in casts, but never presents the shells themselves. It shows a light trace of gypsum, but in neither of these beds does there exist any carbonate of lime. From the character of the organic impressions they contain, they clearly refer themselves to the Miocene formation.

In some places on the river, particularly where the upper bed of the Eocene contains gypsum, as at a point a little below Piping Tree, a thin layer of ferruginous rock abounding in casts occurs immediately in contact with the Eocene; this also is to be placed among the strata of the Miocene.

A more distinct conception of the order and extent of the strata of both the tertiary divisions, as they occur at different points along the river, will be obtained from the following summaries derived from observation.

On the north bank of the river in a cliff about half a mile below Piping Tree, the beds taken in a descending order are,

<i>Miocene</i> .—1. White friable sandy clay, containing fossil impressions,			10 feet.
2. White sandy marl with broken shells,	-		$\frac{1}{2}$
3. Ferruginous stratum abounding in casts, and occasionally containing the shells themselves,			$\frac{1}{2}$
4. Thin band of black pebbles.			
<i>Eocene</i> .—5. Dark greensand stratum—no shells,			4
6. Rocky shelf of cemented shells of the saddle-shaped oyster,	-		$\frac{1}{2}$
7. Dark greensand strata with small shells,	-		2
			17 $\frac{1}{2}$

The highest Miocene bed is not exposed at this point, but occurs a little farther up the river in the character of a dark blue clay with fossil impressions, on which there rests a thin layer of ochreous clay, as brilliant in its tints as the finest chrome yellow. This ochre is of the most impalpable texture when dried, and would be found very valuable in colouring.

At Mr. Washington Basset's, about $4\frac{1}{2}$ miles higher up the river, the bank is precipitous, and presents the following series of strata:

<i>Miocene</i> .—Superficial gravel,	-	-	-	5 or 6 feet.
Thin layer of friable sandy clay with casts,	-	-	-	$\frac{1}{2}$
Olive-coloured earth with shark's teeth, and a few				
casts of Miocene shells,	-	-	-	7
Thin line of black pebbles.				

<i>Eocene</i> .—Dark greenish-brown stratum, containing a large pro-				
portion of greensand, and in some parts				
abounding in shells. The upper portion con-				
sists of a rocky mass of cemented shell,				
chiefly the saddle-oyster,	-	-	-	20

At Walker Tomlin's, on the south side of the river, immediately below Newcastle, the beds are,

<i>Miocene</i> .—Friable white clay and sand with casts of shells,				2
<i>Eocene</i> .—Olive earth with pebbles at bottom,	-	-	-	6
A dark bluish-green clay, containing a great deal of				
greensand, capped by rock as at the former				
locality,	-	-	-	25

At Newcastle and William H. Roane's and Mrs. Ruffin's estates, a similar series of beds occurs, rising still higher above the level of the stream. About $1\frac{1}{2}$ miles above Newcastle, the upper surface of the Eocene marl has an elevation above the river of more than thirty feet. The lower stratum consists of the bluish-green clay before mentioned, containing only a few of the more delicate shells, and richly abounding in greensand; the upper of a gray calcareous marl, thickly speckled with granules of this substance. Over the whole is a layer of the white friable material, with Miocene impressions.

The upper surface of the Eocene usually presents an unbroken line, though at some places, as at Mr. Fox's above Newcastle, this is not the case. The bed here consists of a light-coloured sand and clay, speckled with the greensand, and containing vast numbers of the Eocene oyster. Its outline presents numerous cavities and eminences, exactly resembling those which occur in the Miocene deposit nearer to the seaboard. A narrow layer of common sand

deeply tinged by mixture with greensand, lies immediately upon this irregular surface, and the whole is covered with a bed of gravel and sand, with diagonal lines of stratification, indicating the agency of currents at the time of its deposition.

At Mr. William Wickham's, the overlying stratum consists of bands of ferruginous gravel and sand, containing round concretions, like Geodes, generally filled with sand. Thin seams of iron ore run along this stratum a few feet above the fossiliferous beds. These latter, in some places, present a level outline, and are then always covered by a layer of sandy clay containing much greensand. On the other hand, where the outline is undulating and irregular, a stratum of gravel rests immediately in contact with the bed of marl. The size of the gravel thus deposited, as well as the scooped surface of the bed on which it reposes, indicating the operation of powerful currents after the deposition of the strata of Eocene, presents an explanation of the absence in these places of the upper bed of this formation, remarked as present in those spots, where there are no such indications of the action of destructive forces. The matrix of the fossils is sometimes an olive-coloured clay, sometimes a grayish-green sand and clay, and sometimes a bluish-black clay, containing a large proportion of the granules of greensand. The depth of the marl is 15 feet.

EOCENE STRATA OF THE JAMES RIVER.

The beds of Eocene on the James river first make their appearance on its southern shore near Coggin's Point, and thence continue, except when interrupted by the river flats, to a small distance above City Point, making a distance following the flexures of the shores of about ten miles. On the opposite side they have been found at Berkeley and other points, but as yet this portion of the deposit has been but little examined.

At Coggin's Point, Tarbay and Evergreen, the cliffs have a height varying from 30 to 40 feet. The Miocene marl, which in some places is seen overlying the Eocene, abounds in scallops and other shells which make it easily recognised. Beneath this and usually separated from it by a thin line of black pebbles, like those occurring on the Pamunkey, there occurs a stratum of a greenish-red and yellow aspect, containing much greensand and gypsum; the latter partly disseminated in small grains, and partly grouped in large and massive crystals. The under stratum, rich in greensand and con-

taining a few shells in a friable condition, extends to some depth beneath the level of the river, and appears to rest upon a bed of clay of a lead colour, containing crystals of gypsum. At Evergreen a stratum of pure white clay rests upon the upper layer of Eocene, containing, embedded in its lower surface, large groups of crystals, and seems to occupy the place of the black pebbles before mentioned. The whole thickness of the Eocene deposit at this point appears to be about twenty feet. Below as well as above this place, its height declines until no portion of it is any longer visible above the water edge.

EOCENE DEPOSITE OF THE POTOMAC, RAPPAHANNOCK AND MATTAPONY, &c.

Although the shores of these rivers have as yet been but little examined with a view to the structure and arrangement of the various strata they exhibit, enough has been observed to prove that they are no less rich in the Eocene marl than the other districts which have been described. On Potomac creek, and for a great distance below its mouth, the greensand strata may be seen running along the base of the cliff; and from specimens examined, there can be no doubt that the character of the deposit is similar to that of the Eocene of the James river and Pamunkey. On the Rappahannock, for a considerable distance below Port Royal, the very same appearance is presented; and the greensand obtained from some of these localities is in every respect like that from the points already noticed. In some places on the Mattapony, the occurrence of the greensand stratum has been ascertained, while in others the beds containing this substance are replaced by beds of clay, which, though geologically of the same (or Eocene) formation, are yet less likely to prove interesting to the agriculture of the vicinity. Minute inquiries throughout all this district, and throughout the corresponding region south of the James river, are alone capable of developing the extent and value of this deposit. Even a great deal yet remains to be done in investigating localities on the James and Pamunkey rivers, the northern shore of the latter being so far almost unexplored, and the precise character and value of some of the beds in localities examined being but imperfectly ascertained.

OF THE SEVERAL BEDS COMPOSING THE EOCENE FORMATION.

In treating of the accompanying Miocene in the beginning of this section of the report, our descriptions have been confined chiefly to those beds which occur remote from the rivers upon the highlands, and no mention has been made either of the white friable sand or olive-coloured clay already frequently noticed in describing the overlying strata on the Pamunkey.

The first of these, though once the repository of shells and other fossils, is now entirely destitute of carbonate of lime. A small quantity of gypsum in a minutely divided state seems to be its only ingredient of any value, and the amount of this present in the specimens I have examined is much too inconsiderable to give the material any agricultural importance.

The olive earth, which is frequently an extensive layer, has also lost all the calcareous matter which it once contained; but a further examination, chemical and geological, of this material, will be required before its nature can be exactly determined, or the possible applications of which it may admit can be ascertained.

The upper bed of the Eocene, characterised in most of the localities by the gypsum which it contains, is worthy of especial consideration on account of this valuable ingredient. In specimens from the James river, from five to eight per cent. of this substance has been found in a divided state, at the same time that a considerable additional quantity in a massive form exists in various parts of the same stratum.

On the Pamunkey this stratum is not so thick, and is perhaps less abundant in the sulphate of lime. The lower beds, in some cases containing a marked proportion of shelly matter, and in others having almost none, are more especially distinguished by the larger proportion of another and even more important ingredient, to wit, the greensand. Both on the James river and the Pamunkey, their richness in this material gives them an agricultural value which perhaps no proportion of calcareous matter by itself, however great, would be able to impart. The illustrations of its beneficial effects, and the general observations upon its employment as a manure or marl, which will hereafter be presented, will, I think, manifest the justice of this opinion, and give a sound confidence to those who are disposed to make trial of its powers.

EXTENT AND COMMODIOUS POSITION OF THE EOCENE ON THE RIVERS.

One of the most interesting facts presented in the foregoing description of the Eocene on the Pamunkey and James rivers, is the great depth and extent of those strata, which, from the nature of their contents, may be applied to profitable use in agriculture. Beds of such materials, preserving an average thickness of twenty feet, extend along the banks of the Pamunkey with occasional interruptions for more than twenty miles.

Their position on the river shore makes them of most convenient access, and gives additional facilities to the conveyance of the fertilizing materials they furnish to various distant points, while from the peculiar character of the strata themselves, they are almost exempt from the usual destructive agencies of the freshets, being of a texture to withstand with scarcely any loss the most violent assaults of the sweeping currents by which the banks of the river are so often overflowed. To this cause we are to ascribe the steep declivity of the shores in many narrow parts of the river, where the abrading action of the water, instead of rapidly carrying off the materials of these strata, has merely served to wear them into smooth and almost perpendicular precipices rising immediately from the margin of the stream.

EXISTENCE OF THE EOCENE BENEATH THE HIGHLANDS, AND THROUGHOUT THE WHOLE BREADTH OF THE STATE.

The general position and direction of the Eocene beds suggests another view of great practical importance to this and the neighbouring districts of the state. I allude to the probable, perhaps I may say certain, continuation of these strata over a wide area, on a level corresponding to the general depth at which they are found upon the rivers. In confirmation of this view it may be remarked, that since the publication of a communication on this subject in the Farmer's Register, the existence of a similar deposit throughout an extensive district of Maryland, lying in the general direction of our Eocene formation, has been brought to light, and there is reason for believing that within the borders of North Carolina, near to the Virginia line, the same strata are displayed in the banks of several of the streams. In the belief then that all this extensive band of country, stretching in a meridional direction entirely across the state,

rests upon strata of this description, we are led to regard it as furnishing an immense addition to the resources of the state, and as holding out to our enterprising farmers situated within its limits, a new motive to persevering and active research. Let it not be supposed, however, that wherever the Eocene occurs within our state, it will be found to present the same materials in the composition of its strata, as have been found in the localities already examined. Much diversity in this respect may, and probably does exist. On the Mattapony, as already stated, the greensand is frequently replaced by beds of clay of a dark lead colour; while on the Potomac, Rappahannock, Pamunkey and James, variable but generally large proportions of the greensand occur, and the probability is, that future inquiries will develop similar diversities in the materials of the beds in other yet unexplored portions of the district. Constancy in the character of the embedded fossils is all that is necessary to a geological identity of the formations, and this constancy may exist at the same time that there is a considerable diversity in the materials in which they are enclosed. It is almost certain, however, that throughout a large portion of the region in question, extensive and valuable beds containing the greensand do exist, and that even in the highlands they might be reached by excavations descending not very far beneath the lower limit of the Miocene or ordinary marl.

ON THE VALUE OF THE EOCENE GREENSAND MARL IN AGRICULTURE.

From the descriptions already given of the materials of the various beds of Eocene, it will be seen that many of them contain ingredients which have long been recognised as valuable when applied to land. The gypsum in some, and the carbonate of lime in others, will at once bespeak the favour and confidence of the agriculturist, and no observations, either as to their usefulness or mode of application, will be necessary to give them the importance they deserve. But the *characteristic and principal* ingredient of a large number of these beds, the *greensand*, possesses claims to our attention which are equally indisputable, though not so generally appreciated or understood. Experiments within our own state on this material, as furnished by the Eocene deposits, though few, and on a very limited scale, have been so far satisfactory. But as the marls containing this substance, which have been employed, have also in most cases contained a notable quantity of gypsum, or of calcareous matter, all

the benefits which they have produced would most naturally and reasonably be ascribed to those ingredients, already known for their agency in ameliorating the land. On the Pamunkey the Eocene marl has long been in use, but chiefly those beds have been selected for the purpose of marling in which the largest proportion of calcareous matter was seen to exist. The lower layers, containing little or no calcareous matter, have on that account, until lately, been rejected as useless, and sometimes when a bed of this description of considerable extent was found immediately overlying a more shelly stratum, much trouble and expense have been incurred in its removal, to make way for the excavation of the material beneath. Appealing to the experience of the farmers of New Jersey, by whom the greensand, in an almost unmixed condition, has long been applied for the purposes of a manure, its unrivalled efficacy, and the permanency of its ameliorating effects, are to be regarded as established and unquestionable facts. It is true, that at one time, owing to the ignorance of those who attempted to make use of it, and the application frequently of a spurious material resembling it in aspect, doubts of its value have been excited in the minds of some; but the extensive and uniform experience of the present enterprising farmers of that state, gives an unqualified testimony to the rapidity, the power, and the durability with which it acts.

A comparatively small dressing of this marl, often not exceeding ten or fifteen loads per acre, is uniformly attended with beneficial results, and this, whether the soil to which it is applied, be a clay, or a light sterile sand. As an illustration of this fertilizing property of the greensand, I will subjoin the following statement quoted from the report of my brother, Professor Henry D. Rogers, on the geology of New Jersey, to which work I beg leave to refer, for ample and satisfactory details relating to the agricultural value of this substance, as well as for practical suggestions as to the most judicious modes in which it may be applied:

“When we behold a luxuriant harvest gathered from fields where the soil originally was nothing but sand, and find it all due to the use of a mineral sparsely disseminated in the sandy beach of the ocean, we must look with exulting admiration upon the benefits upon vegetation, conferred by a few scattered granules of this unique and peculiar substance. The small amount of greensand dispersed through the common sand, is able, as we behold, to effect immeasurable benefits in spite of a great predominance of the other mate-

rial, which we are taught to regard as by itself so generally prejudicial to fertility. This ought to exhibit an encouraging picture to those districts not directly within the limits of the marl tract, where some of the strata possess the green substance in sensible proportion. It expands most materially the limits of the territory where marling may be introduced, and points to many beds as fertilizing, which otherwise would be deemed wholly inefficacious."

If such then be the effects of this material, even under circumstances where comparatively little advantage could have been anticipated, and if such moreover be the concurrent experience of those by whom it is daily and extensively employed, we are fully authorised in the belief, that in the Eocene beds of our own state, though in general less rich in the fertilizing ingredient than the secondary strata of New Jersey, the agriculture of eastern Virginia possesses a new and most valuable resource.

The chemical examination of these marls, with a view to precise results, being a matter requiring much time and labour, has as yet been carried on only to a small extent. But, a thorough analysis of all the important varieties and an exact determination of the proportion of the various constituents, especially the greensand, or the calcareous matter in different localities, will be a work from which much practical good may be derived. By the light of such results alone, can the farmer be safely directed in applying it to the soil, or be properly guided in distinguishing between a material which is spurious, and one which will be found salutary in its effects upon the land.

The following results are to be looked upon as approximate determinations, but will serve to illustrate the composition of several varieties of the marl :

COMPOSITION OF GREENSAND (EOCENE) MARLS.

Doctor Corbin Braxton's,	Silica and alumina, &c.	50
	Carbonate of lime,	10
	Greensand,	38
	Gypsum,	2
Walker Tomlin's, lower stratum,	Silica and alumina,	60
	Carb. lime and gypsum, <i>a trace.</i>	
	Greensand,	40
Conrad Webb's,	Silica and alumina, &c.	30
	Carbonate of lime,	45
	Greensand,	25

Wm. H. Roane's, lower stratum,	Silica and alumina, &c.	50
	Carb. lime,	4
	Greensand,	46
	Gypsum,	3
Tarby, lower stratum,	Silica, alumina, &c.	40
	Carb. lime,	3
	Greensand	57
Do. upper stratum,	Gypseous earth containing	
	from 6 to 10 per cent. of gypsum, and from 10 to 15 per cent. of greensand.	
Berkeley,	Silica and alumina, &c.	50
	Greensand,	50

Viewing these results generally, it is apparent, that while in some cases the efficacy of the marl would be ascribable in a degree to the calcareous carbonate or sulphate present in large proportion, in a great many others the greensand ought to be regarded as the chief, if not the only agent in the effects. A dressing of many of these marls to the extent usual in the application of the Miocene shell marl would scatter upon the soil a proportion of greensand, nearly as great as the average quota which is at present in use in New Jersey, and in the richer sorts, a much less proportion would be necessary than it is customary to apply where the shells abound.

We are struck, in considering the composition of these marls, with the happy variety of constitution which they exhibit, which, should there be any specific action of the respective ingredients on particular vegetables, which there is reason to believe is the case with one (the gypsum,) will the more completely adapt them to the variety of crops to which the farmer would wish them to be applied.

Some caution will be necessary in distinguishing the marls, containing a large proportion of greensand, from dark greenish clays and sands, which have sometimes been mistaken for them. These clays are always entirely destitute of fossils; they have an astringent or copperas flavour, and generally a strong sulphureous odour, though a slight smell of this kind is also often observed in the best marls. The occurrence of small shells sparsely distributed and in a decomposing state is very frequent in the good marls, though an almost total absence of shells is sometimes observed. Fine sparkling scales of Mica, (not gypsum, as supposed by some,) are generally present in considerable proportion, and have led those who speculated upon

the action of the marl, to ascribe a large part of its efficacy to the supposed sulphate of lime or gypsum contained in it. To distinguish a marl of this kind from the dark blue Miocene marl, a slight attention to the embedded fossils will be sufficient. The saddle-shaped oyster, characteristic of the Eocene, and never found in the later deposit, would at once determine the bed in which it is found to be of the former description—while the common scallop or clam, which is never seen in the Eocene, would indicate the Miocene character of the bed in which it lies.

In concluding what I have to say upon this important topic, I may be permitted to throw out the suggestion, that should the deposit of which I have been treating, be found as extensive in its range and as useful as a manure as here anticipated, the districts of the state contiguous to its western limits, as well as the region in which it occurs, might be expected to reap important benefits from its employment. Parts of Henrico and Hanover, and the lower part of Louisa, in which no marl exists, would be sufficiently contiguous to the Pamunkey deposit to avail themselves profitably of its use, and when the projected improvements in this region of the state shall present cheaper and readier means of transportation to the remote parts of the two latter counties, as well as to a portion of Goochland, it is not extravagant to hope that this material may be conveyed to those districts at such a cost as will render it a profitable as it would be an efficacious restorative to the exhausted and sterile soils to which ameliorating applications have of necessity hitherto been denied.

To other parts of the state in a corresponding position, perhaps similar benefits might be dispensed, and thus most of that portion of the state beyond the reach of the limestone which ranges a little east of the S. W. mountain, would in time be brought under the beneficent influence of the marls of the western limits of the Eocene formation.

REGION BETWEEN THE HEAD OF TIDE AND THE WESTERN FLANK OF THE BLUE RIDGE.

The various geological features of this extensive division of the state are peculiarly interesting, and at the same time difficult of investigation. To trace the limits of the formation of an undoubted primary character, occupying the region towards its eastern border, and to ascertain the extent of the overlying rocks, connected with

the valuable bituminous coal of eastern Virginia, is of itself a task in which much time and industry could be advantageously employed. To investigate minutely the relations and character of the various rocks with which the auriferous quartz of the region adjacent to the western limits of the former, is associated, and to ascertain the number, direction and relative value of these veins, so productive in the precious metal, would also be a business requiring much laborious and discriminating observation; while, in the remainder of the district of which we are now treating, multiplied and accurate researches, directed to numerous lines across its surface, would be indispensable to correct views of its geological details; to the removal of the many obscurities in which its structure in numerous points is as yet involved, and to the really useful development of its great mineral and agricultural resources. In the brief period allotted to the reconnoissance, therefore, the attainment of much minute knowledge regarding this region was not to be anticipated, although while aiming at the determination of interesting points of general inquiry, it was always deemed an important object to collect useful details, calculated to throw light upon the resources as well as the structure of this region.

Before entering upon the description of the strata of primary and other rocks of a very ancient character, of which this region is in the main composed, it will be most convenient to treat of the interesting formations, including the bituminous coal of eastern Virginia as well as of the sandstones overlying the tide water borders of the primary.

GEOLOGY OF THE BITUMINOUS COAL FIELD INCLUDED IN THE PRIMARY REGION.

Of the extent and exact geographical limits of this truly interesting coal formation of eastern Virginia, too little is yet known to warrant more than a few words to designate its general position and relations to the other strata. We shall dwell, however, upon one or two points connected with its internal structure, of great moment to all those who are interested in the further developement and working of its coal seams.

It will be apparent by a reference to the general profile or geological section across the state, that the sandstones and their associated coal seams, which make up the formation before us, rest in a narrow trough in the primary strata. Whether the

group is characterised by containing coal to a greater or less amount throughout its whole extent, is yet a question, and one which can only be determined after minute and elaborate investigation. Traces of good bituminous coal are detected at intervals over a space of nearly 35 miles in length, from the South Anna near its mouth to near the Appomattox river; but there is nothing to assure us that the sandstone in which the coal occurs, does not range, at least in some directions, beyond the limits where the coal itself thins away and disappears. Towards the central part of the formation,—namely, within a few miles on either side of James river,—the coal appears to be thickest; and it is there accordingly, where the deposit has alone been worked, that we can collect facts enough to lead to any general views of a practical bearing regarding the structure of this coal field. Where our section crosses it,—namely, through the estates of Mr. Wickham on Tuckahoe creek,—the width of the coal tract is about four and a half miles. It seems to expand in width as we follow it to the south side of James river, being in a section drawn through the Black Heath mines, probably eight miles across from the eastern to the western outcrop of the primary strata, which compose the floor upon which the coal-bearing group reposes. The probability is, that this is nearly the centre of the basin, and the widest part of it, if we are to judge from the fact, that the coal exists in greater thickness here than at any place either further north or south.

The thickness of these coal seams is very variable; the great lower mass which reposes within two feet of the primary rock, in the Deep shaft and other adjacent mines in Chesterfield, is estimated to be 40 feet from its upper to its lower surface. Over this there is another thinner seam, five or six feet thick, separated by a few feet of coal shale. A third, still thinner band of coal, is found between these in some of the mines. Upon the opposite or western side of the basin, two separate seams are wrought in several of the mines. At Anderson's mine, the upper seam varies from six to sixteen feet in thickness—the lower, separated from it by 30 feet of slate and sandstone, is from four to eight feet, and rests almost immediately upon the top of the primary rock. At Willis' and Crouch's mines, on the south-east side of the coal field north of the river, there are also two principal seams, the upper being five feet, the lower about four feet thick, and separated from each other by 11 feet of slate. In both these points as elsewhere, the upper seam

is invariably the purest coal. We have thus, at a distance of nearly 10 miles from each other, two localities, showing sufficient correspondence in the relations of the seams to each other and to the adjacent strata, to establish the continuity of the same beds across the whole coal field.

In some of the shafts on Tuckahoe creek, as many as five separate seams have been struck, of thickness sufficient to justify working, and there exist many more of insignificant dimensions which are neglected. There are good local reasons in several parts of the coal field on the north side of the river for believing, that the seams occasionally coalesce, so that two become but one.

We do not conceive it essential to the objects of the present report, to specify anything more respecting the local details of the numerous mines in this coal field, than is requisite to make its importance and peculiar structure understood.

On the south side of the James river, an old mine, called the River pit, now deserted, contained at the depth of 130 feet, a seam of coal 20 feet thick, but which, owing to a close approach of the granitic floor to the sandstone roof, was so reduced in thickness as to be abandoned.

Upon the east side of the same portion of the basin in Mills' mines, the coal varies rapidly in thickness, from almost nothing to upwards of 40 feet, and in one place to sixty feet, if we include thin bands of the coal shale. In the Midlothian pit the shaft is 500 feet in depth, and the workings are carried to the depth of 700 feet below the soil. The coal is very variable in thickness, being worked at more than 30 feet, and in some places it is even thicker. In this mine, as in several of the adjacent ones, we have numerous instances of the coal filling up hollows as it were in the floor, being accumulated in saucer-shaped basins to the thickness of 40 or 50 feet, and resting in comparatively thin masses upon the *eminences* in the same floor. In some instances, these subordinate basins are almost entirely insulated from the rest of the coal field, and are presented under features which preclude us from supposing that they owe their shape exclusively to the numerous faults which intersect the strata. Upon the north side of the river near Tuckahoe, the coal was reached precisely in the centre of a small insulated cup-shaped depression. The coal as it was pursued, was found to rise gently on all sides from the shaft, and also to thin away from a thickness of four or five feet to two feet towards the edges of this shallow basin,

which was several hundred feet in diameter, and but little disturbed from its original nearly horizontal position.

It should be remarked, that while the under surface of the coal resting almost in contact with the primary rock, assumes its unevenness of outline, the upper surface is also affected by similar undulations, though to much less extent, which only goes to show that the deposition of the coal did not sufficiently fill up the original inequalities upon the floor, to make a perfectly level surface for the reception of deposits which succeeded.

Of the nature of the dislocations or faults, too little is at present known to enable one to generalize or say much upon this truly important topic. The greatest number of pits being upon the eastern border of the coal field, it is there that the faults or troubles, as they are generally denominated in this region, are best seen. Along this outcrop of the coal, there would seem to extend over a great space one or more very remarkable lines of dislocation, throwing up the coal to the west by a heavy fracture, so as to make of the same seam a double outcrop, and over a distance of perhaps half a mile, bringing the subjacent granite itself again into view. We witness, therefore, over a portion of the eastern side of the coal field, two parallel ranges of collieries, less than a fourth of a mile asunder. The Black Heath mines, the Union mine and the Deep run pits are said to lie along the outer crop, though it is questionable whether one and the same fracture extends over so many miles of strata. The probability is, that several nearly parallel fractures will be found traversing this side of the region, and tending to the intricacy and difficulty of successful mining. In fact, three extensive faults affect the strata near the Black Heath mines, the outer one causing the upthrow before stated, and the others producing heavy downthrows to the west.

It would seem, that transverse to these more important and serious fractures, which generally pursue a direction nearly parallel to the general line of outcrop of the coal, there are innumerable other more trivial breaks and displacements, sometimes straight, but oftener irregular in direction and dip, which still further intersect the strata, dividing them into a multitude of nearly detached and broken basins. An exact knowledge, more particularly of the great longitudinal faults, is especially desirable for directing with system the mining operations of this coal field.

There is one general fact of much practical interest disclosed in

nearly all the principal mines of this whole coal field—It is, that the main body of the coal lies either in direct contact with the primary rocks, or closely contiguous to them. This furnishes a highly important guide, or in fact the only unerring one, in the prosecution of new or intricate workings; for, it suggests the utility of making the primary rock the object towards which the mining should be pursued whenever a difficulty occurs in regaining the coal displaced by a fault; for, if we are surrounded by sandstone, we may be sure that the chief deposit of the coal is to be reached by penetrating across the strata towards the subjacent granitic floor.

The sandstones being all of them nothing more than the debris of the subjacent primary strata recemented, they resemble them occasionally so much as to render it difficult to the inexperienced to distinguish the two classes of rock; though the discrimination in this case is all important. The aid of a pocket magnifier will detect a less angular character in the materials of the sandstones than in those of the primary rock.

The general range or longitudinal direction of the coal field, or what is the same thing, the line of bearing of the outcrop of the coal, is nearly N. N. E. and S. S. W. The structure of the coal field is that of a true but very oblong basin, composed of a thick series of variously constituted sandstones super-imposed upon two or three seams of bituminous coal, themselves resting almost immediately in contact with the surface of the primary rocks of the surrounding region. Wherever the eastern boundary of the coal field has been traced, the beds of gneiss or stratified granite are seen to dip apparently with considerable regularity to the west, or beneath the coal, and in like manner upon the opposite or western edge of the tract, the same rock is known to have a general dip under the coal to the east; suggesting the notion, at first sight, that the strata pass horizontally under the middle of the coal field. That this is not necessarily the case, will appear presently.

The usual angle of the primary strata to the horizon is about 25 or 30 degrees. Between the city of Richmond and the edge of the coal field at Tuckahoe pursuing a progress westward, the dip of the strata for the first several miles, is at a gentle angle to the E. and N. E. varying sometimes to the north. Near the coal, the point towards which the strata are dipping, is more nearly the N. W. or occasionally more west. A similar change of dip is seen in passing over the edges of the strata on the eastern side of the coal

field upon the Chesterfield side of the river. Tracing the dip of the gneiss rock westward, from the western outcrop of the coal, we find it to be towards the S. E., or beneath the coal field, and this throughout a width of several miles in our course west, until we approach the Beaverdam creek; here, for a short space, the dip is altered to the west, but the easterly direction is after awhile resumed, as we approach Goochland courthouse. Between five and six miles further on, or in the vicinity of Little Lickinghole creek, the dip is over more to the west. These various alternations in the position of the strata, are specified for the purpose of showing how probable it is, that the coal strata within the basin were originally deposited in a valley formed by the meeting of an eastern and western dip; in other words, upon the edges of the strata composing a *synclinal* axis, and not upon a horizontally placed stratum of the gneiss rock. The former view will help us more naturally to account for the very striking inequalities in the thickness of the bed of coal resting nearly in contact with the ancient surface of the primary rock. Had the ancient rocky floor, upon which the materials that formed the coal were deposited, been the gneiss rock in nearly horizontal stratification, it is hard to conceive how any subsequent dislocations of the whole group by upthrows and downthrows could introduce that remarkable degree of unevenness in the thickness of the coal seams over the small areas for which this coal field is so peculiar. Everything lends countenance to the opinion, that the surface of the primary rock, previous to the deposition of the carboniferous matter, was a valley of rolling outlines occupied by hollows and elevations, causing the first layers of matter which were thrown down to be deposited in greater thickness in some places than in others. As the lowest coal seam is separated from the crystalline rock beneath by only a very few feet of shale, and in some cases by none at all, it appears likely that the distribution of the coal was made unequal in thickness from the very commencement. There is ample proof that subsequently to the consolidation of an enormous thickness of sandstone over the coal, the entire series of beds, including the underlying primary strata, were reft by a number of extensive cracks, producing displacements of the beds, which combined with the original irregularity in the distribution of the coal itself, has caused the internal structure of this coal field to be one of excessive intricacy. These views are stated for the purpose of indicating the necessity of boring as the best and surest

means of ascertaining the value of particular parts of the formation. For it must be plain that the ordinary mode of mining, applicable to other coal fields, may be ruinously fallacious when applied to this. The intricacy of the faults, and the changing thickness of the coal, are features calculated to baffle and defy the anticipations of the miner. A profound knowledge of the nature and extent of the local disturbances around him, together with some general rules applicable to all coal mines, may enable him to approximate with considerable accuracy to the depth and position at which he is to meet the coal seam, but he can form little or no anticipation from knowing its thickness elsewhere, what its thickness will be when he reaches it in the new place. In most coal fields he may. The reason of the difference is, that in the present case the coal lies almost immediately contiguous to the undulating surface of the primary rocks below, and must partake, especially in its lower surface, of the plain upon which it was deposited. In most other coal regions the underlying rocks are either sandstones, limestones or slates, themselves originally horizontal deposits furnishing a level floor upon which the carboniferous matter would necessarily spread itself in an even sheet.

What is here said is not intended to throw a damp upon enterprise which is pursuing the developement of this coal field; on the other hand, we regard it as one of the most valuable deposits of mineral wealth within the area of Virginia. Our duty is by practical suggestions derived from the best sources within our reach, to promote a sound direction to the enterprise and capital employed upon the mineral resources of the state—to teach caution where necessary, but not to discourage.

The fine qualities of the coal in this coal field, both for domestic uses and manufacturing purposes, together with the very enormous thickness of the deposit in many of the mines where it is pursued, hold out an ample guarantee, that if prosecuted upon a correct conception of its internal structure, it must always prove a profitable region to the quarter of the state in which it lies.

There is one suggestion which we venture strenuously to enforce—the great importance of preserving specimens of the various layers of rock penetrated by the shafts which are sunk from time to time, or in any borings that may be made. The rocks resting above the coal are less liable to be affected by local variations than the coal itself, for reasons previously explained—and most important

inferences might be drawn as to the depth of the coal, by comparing the rocks as they are crossed in succession with sets of specimens of the same collected from the adjoining mines. Data will thus be rapidly accumulated, from which we shall one day be able to infer much better than at present, the extent of certain faults or downthrows, the nature of which can as yet be only imperfectly understood from the evidences produced in the workings of the mines. Nor is it too much to anticipate being able to compute from information thus derived, the depth from the surface of the coal in some places in the interior of the basin.

To show the constancy of certain layers of rock in particular districts, and their importance as a guide in particular situations, we may adduce a case given by Professor Phillips of a band of fossiliferous rock subordinate to a coal field in England. Speaking of a certain seam in the Yorkshire coal field, generally not much more than 16 inches in thickness, and traceable from near Leeds to the west of Sheffield, it is stated, "That it would have been impossible to have traced so thin a seam of coal along so extensive a range, without some peculiar facilities, some points of reference more distinct than the varying quality of the coal, and the still more irregular fluctuations of the sandstones and shales. This coal seam is covered by a 'roof' unlike that of any other coal bed above the mountain limestone in the British islands; for, instead of containing only the remains of plants or fresh water shells, it is filled with a considerable diversity of *marine shells* belonging to the genera *Pecten* and *Ammonites*, and in one locality, specimens of *Orthoceras*. The uniform occurrence of these *Pectens* and *Ammonites* through so wide a range, over one particular thin bed of coal, and in no other part of the coal strata, is one of the most curious phenomena yet observed, concerning the distribution of organic remains, and will undoubtedly be found of the highest importance in all inferences concerning the circumstances which attended the production of coal."

We may gather from this the importance of inspecting the sandstones for fossil remains, should any exist.

The mining shafts hitherto sunk in this region, have been confined exclusively to the vicinity of the eastern and western outcrops, from an apprehension, that more in the interior of the basin, the coal reposes too far from the surface to be readily reached. By following the banks of the James river above the mouth of Tuckahoe creek, it will be seen that the coal metals,—that is to say, the sand-

stones,—overlying the coal, after dipping throughout some distance at a moderate inclination to the north-west, become gradually almost horizontal, and continue so over much of the middle space between the eastern and western boundaries of the basin. This, certainly, implies the absence of any heavy dislocations affecting the middle tracts of the coal field, and is one feature calculated to support the notion of boring for coal in that quarter. From what has been said respecting the probability of an undulating surface in the subjacent gneiss or granitic rock, and of the faults which intersect the region, it becomes by no means improbable, that the coal in the centre of the basin will be found, in some places at least, sufficiently adjacent to the surface to admit of being profitably mined. General analogy would lead us to look for accumulations of coal in that quarter, if not thicker, at all events as thick, as can be seen near to either outcrop. But the resources of the middle portion of the coal field can only be imperfectly guessed at, until there has been gathered a much larger mass of minute information from the borders of the region. We do not yet know any thing definite regarding many portions of the limits of the basin, more especially the western outcrop—and there is moreover much to do in following the coal where it is already tolerably well known.

The deepest shaft, that of the Midlothian mine in Chesterfield, is 500 feet to the coal; and the workings connected with the same mine, in consequence of some very heavy downthrows to the west, penetrate to the depth of 700 feet below the surface. There is some reason to believe, that still further from the outcrop, there will be found an upthrow, bringing the coal once more nearer to the soil. It is possible that a shaft one thousand feet deep, would reach the coal in several places in the interior of the coal field.

In addition to the invaluable deposit above described, coal veins have been discovered in Prince Edward and Cumberland counties—and the rocks accompanying this mineral, are known to extend over a wide area in this portion of the state. Their thickness, compared with those of the coal fields previously described, is, however, not considerable—and the seams of coal which have been met with, though containing a very excellent material, are on a comparatively limited scale. The probable extent of coal in this district, appears as yet entirely undetermined, and will remain so until an examination of this portion of the state has been carefully and minutely made. The discovery of coal within a small distance of the base of Willis'

mountain, recently said to have been made, derives peculiar interest from the fact of the existence, in the same vicinity, of hematite and magnetic iron ores in great abundance.

SANDSTONES OVERLYING THE PRIMARY ROCKS ALONG THEIR EASTERN
BOUNDARY.

Sandstones of various degrees of coarseness are found in many places along the eastern outcrop of the primary rocks, and extending for some distance below the head of tide. On the Rappahannock, in the vicinity of Fredericksburg, considerable exposures of these rocks are seen, the strata lying nearly in a horizontal direction upon the edges of the primary rocks beneath. At Falmouth, the two are seen in contact; the latter forming the bed of the river, and the former resting horizontally upon them. At the head of the Pamunkey, the same rocks appear, dipping with some steepness to the east; they are again met with, gently inclining in the same direction, a short distance below Richmond, and also in the neighbourhood of Petersburg, and at several points in Chesterfield county. Further south, they occur in the upper part of Greenville, and over a considerable portion of the county of Brunswick, and, as is believed, in portions of the adjoining counties.

In composition they are merely a mixture of quartz and felspar, in rather loose cohesion—the felspar often decaying rapidly on exposure. In some varieties, the rounded pebbles are not larger than birdshot; in others, they attain a diameter of many inches. In certain localities, the sandstone has a fine close texture, suiting it for various useful purposes, and is employed to a considerable extent in building. The quarries in the neighbourhood of Fredericksburg and Acquia creek, present beds of great thickness of a homogeneous rock of this description, of which extensive use has been made in some of the public edifices in Washington, Richmond, and elsewhere. In the superior portion of these beds, Lignites, silicified wood, and vegetable impressions, are frequently to be seen—all of which contribute to render the examination of these deposits a subject of much curious interest to science. Whether these sandstones be in reality contemporaries of the analogous, though somewhat differing rocks of the coal measures of eastern Virginia, impressed with peculiarities as to texture, and included fossils by some circumstance of position and exposure in the progress of their deposition

—or whether, as has been maintained, they are in fact of a decidedly more recent origin, are points only resolvable by cautious and diligent investigation.

In connexion with these sandstones and the rocks of the coal measures, there occur in several places beds of earth sometimes having nearly the firmness of a soft rock, containing a considerable proportion of calcareous matter. In Prince Edward, where their existence was first particularly remarked by Dr. Morton, these clays and semi-rocks are occasionally so liberally impregnated with this substance as to furnish a strong and valuable marl. At other points, a mixture of carb. of lime and carb. of magnesia is found in beds of considerable extent, and having a texture similar to the materials above described. According to an analysis of a specimen of this substance from Bear Island, it consists in 60 grains of

Carb. of lime,	31
Carb. of magnesia,	18
Alumina,	3
Silica,	7
Loss,	1
	—
	60

The occurrence in many parts of this region, of clays and rocks thus abounding in calcareous matter, is certainly to be looked upon as a happy circumstance. Those interested in availing themselves of the fact, should have no difficulty in the application of these substances in the raw, or if necessary, in the calcined condition; for, even should they generally contain any notable proportion of magnesia, the more enlightened experience of the present day would seem to show that the presence of that earth is rather favourable than injurious when associated with lime, and in some cases almost equal in efficacy to calcareous matter itself.

There is moreover another economical aspect in which this material may be regarded. From the large proportion of magnesia it contains, it would furnish an admirable resource for the manufacture of that earth in the state of pure carbonate, or of what is at present an object of much more extensive commerce, I mean the sulphate of magnesia, or epsom salts.

OF THE PRIMARY ROCKS.

As already stated, the extent of this portion of the state is not accurately known. Its eastern limit coincides in general with a transverse line crossing our principal rivers at their lowest falls. Various species of gneiss rocks and granite are exposed at these points, some of which are beginning to be known for their valuable qualities as a material for building. At Richmond these strata occur in heavy beds inclining at various angles to the east, and are well exposed along the canal for some distance above the city. The rock at Richmond is a grayish-white gneiss of great density, and of such a degree of hardness and toughness combined as to impart the double advantage of durability and facility of being wrought. Its predominant constituents are felspar and quartz. Dark mica is sparsely distributed through it, so that its prevailing colour is a light gray. It is in consequence of its large proportion of felspar that the rock in many places is observed to be decayed to so great a depth below its original surface. Those varieties will be found most durable for architectural purposes in which this excess of felspar does not exist. At the falls of the Appomattox near Petersburg, we find a well characterised variety of granite. It possesses a coarse crystalline structure, and consists of yellowish-white felspar in distinct crystals, with a smaller proportion of quartz and a trivial amount of white or light-coloured mica. Other varieties of a more compact and fine texture occur in the same neighbourhood. At some distance farther west, in general the rock is a gneiss, containing a much larger proportion of mica. In the upper part of Goochland, and the other counties at corresponding distances above the falls, gneiss of a more compact texture prevails. A quarry of this at Columbia furnishes an admirable building material. Its texture is nearly that of a compact sandstone, and it is coloured of various shades of gray from the scales of black mica which it contains. A gneiss of a very peculiar description occurs in Willis' mountain, Buckingham, associated with several interesting minerals. The rock is generally of a rich pink or purple, owing to a large proportion of oxide of iron disseminated through it, causing it moreover to be very ponderous. The mica and augite, which appear to be large components of the mass, give it a very brilliant aspect, especially when recently fractured. It is sometimes studded with mi-

nute cells, containing hematitic oxide of iron. Nearly the whole of the principal peak of the mountain is made up of this beautiful rock, which, rising in the form of a wedge to the height of several hundred feet, presents a narrow wall of nearly vertical strata along the summit. The dip is west, and the fragments which have tumbled to the eastern base have rendered this the easiest direction of ascent. From its hardness, and the indestructible nature of its materials, this gneiss will some day possess a value independent of that founded upon its colour, which will bring it into use as an article for building. At the base of the mountain schorl occurs in great abundance, crystallized in long prisms in quartz. Asbestos and kyanite are also found together, with several other minerals chiefly interesting in a scientific point of view.

Westward of this belt of gneiss the rocks assume various intermediate characters, until at length the truly crystalline structure is lost, and numerous forms of slate of very peculiar and equivocal features make their appearance. At what precise points the rocks of unequivocally primary character terminate, future researches must ascertain.

In pursuing the line selected for the accompanying profile, the gneiss, which is found dipping east for some distance beyond the western edge of the bituminous coal formation, assumes a western dip which it again changes for an eastern one, after which another change occurs, and the western dip now continues to the neighbourhood of Columbia. Between this point and Brems, the rocks become vertical, and further west, the dip continues with scarcely any exception, easterly, but very steep as far as the South-west mountain, and even in many lines almost without alteration, to the western base of the Blue Ridge.

The *soils* of the primary region, except ^hwhere the rocks accompanying the coal exist, are remarked for the quantity of clay, often of a very ferruginous character, which they contain. The felspar, which, as already remarked, enters largely into the composition of our gneiss and granite, is in some of its forms peculiarly liable to undergo a decomposition by exposure to the atmosphere. The alkali contained in it is gradually dissolved out, and the clay and silica, its other constituents, fall to powder, and thus furnish the materials for soil. At the same time, the quartz and mica, no longer cemented by the interposed felspar, also separate and mingle with the general mass of clay or sand. The Hornblende possessing

much oxide of iron and some lime, produces when decomposed, a deep red earth, which, in virtue of its composition, is generally found productive.

In accounting for the highly ferruginous soils presented in many places in this district, as at Beaverdam in Goochland, it might at first view appear most plausible to regard them as the product of disintegrated hornblende, derived from the subjacent strata, and certainly in some localities the colour and qualities of the soil may be justly referred to this origin. But there are numerous instances in which the superficial earth or clay is very deeply tinged, while no rock of this description exists in the neighbourhood. Even overlying the sandstone of the coal measures, where the occurrence of this mineral would be next to impossible, soil of a deep ferruginous aspect frequently presents itself. Moreover, in general this red soil forms merely a superficial stratum, often only a few inches in thickness, while the earth beneath, the obvious product of the decomposing gneiss or granite, has a white or gray colour, and scarcely any mixture of the tint which prevails on the surface. In all these cases we must look for the source of the red soil in the extensive region to the west, where nearly all the rocks give rise to it by decomposition, and we must regard it as having been transported to the spot on which it now rests, by some of those sweeping diluvial currents whose action is otherwise attested by evidences of a conclusive character.

The soils containing isinglass or mica, as well as those abounding in the clays derived from the decomposition of felspar, though in their natural state rather deficient in their productiveness, have generally been found to receive great benefit from the applications of lime and calcareous manures; and the district in question may reap great advantage from an extensive application of either. Its vicinity to the Eocene shell and greensand marls, as already indicated, is likely at some not remote day, to prove eminently beneficial to its agriculture, and it were to be wished that the farmers who are interested in its improvement, would promptly take advantage of such facilities of transportation as are likely soon to alter, for the purpose of availing themselves of the resources which nature has placed so completely within their reach.

In the neighbourhood of rocks where the felspar is comparatively abundant, the disintegrating process gives rise to a clay of a pure white colour, and almost impalpable texture. This is the *Kaolin*

of the Chinese, one of the essential ingredients in the composition of Porcelain. Numerous rich deposits of it are to be found in this portion of the state. In Goochland, an extensive bed of this earth has lately been discovered on the estate of Mr. Triplett. Its colour is a dull white. Between the fingers it has the smoothness of the finest flour, and with the exception of a few scattered grains of silex, the whole mass is a perfectly impalpable powder.

By a careful analysis of some of this earth, I find its composition to be as follows: In 20 grains,

Silica,	10.76
Alumina,	6.00
Water,	2.90
Loss,	.34
	20.00

In numerous places in Goochland, Cumberland, Buckingham, and other counties similarly situated, the Porcelain earth occurs in extensive beds, and in many cases in as available a condition as above described. This fact, taken in connexion with the known existence of felspar in the same region, points to the probable introduction at no distant day, of an important branch of manufacture in the state—I allude to the fabrication of the finer description of China or Porcelain, in which such excellence has already been attained by the employment of similar materials in Pennsylvania.

The region on the western borders of that which we have been describing, is marked by the occurrence of talcose and argillaceous slates, micaceous and garnet slates, chlorite slates, steaschist, various modified rocks, and numerous veins of auriferous quartz. The precise nature of many of the rocks occurring in this, which for the sake of distinction, may be called the gold region, cannot be determined without close and persevering attention.

OF THE AURIFEROUS ROCKS.

A general examination of this district suggests a variety of problems of a scientific as well as practical nature, which it would be premature at this time to attempt to resolve. The number and extent of the quartz veins is one of the most interesting as well as im-

portant features in the geology of this region, and it is greatly to be desired that minute observation be directed to the tracing of these veins through the state as far as practicable; to the determination of the general value of each vein now wrought, as well as the study of the efficacy of the various processes adopted for the purpose of separating the gold from the materials with which it is intermixed. There can be no doubt, that with the means now most commonly in use, a large proportion of the precious metal is lost and thrown out with the gravel from which only the larger masses of the gold have been separated. At one of the mines visited during the reconnaissance, the sand and gravel, after having been twice subjected to the usual process of washing, was found sufficiently productive to yield five dollars a day to each of the two persons who were washing it a third time. In some of the mines, more scientific and effectual means, both of conducting the mining operations and the subsequent process for separating the gold, have been introduced, and when these improvements shall have become more generally known, we may hope for much more profitable returns than in many instances have been hitherto obtained. The amazing richness of many of these veins, has attracted enterprise to this branch of mining to such an extent, that the exploration of the most promising auriferous veins, has of late been very actively and successfully pursued.

In Spottsylvania and the adjacent counties, Orange, Louisa, Fluvanna and Buckingham, numerous veins have been wrought for some time; from many of which rich returns have been procured, and under improved modes of operation a still larger profit may be expected. Any detailed account of the various workings now in progress would be inappropriate in the present report, even if the state of our knowledge were such as to warrant statements of a positive nature. Some account of the structure, position and contents of the veins may be introduced as generally applicable to the whole.

The material of the veins is a variegated quartz, sometimes translucent, at others opaque. It is generally of a cellular structure, fractures without much difficulty, and in many instances contains a considerable proportion of water, dispersed through its substance. Its surface, recently exposed, displays a variety of tints of brown, purple and yellow, of such peculiar aspect as to resemble a thin lacquer spread unequally over the rock. The cavities are often filled with a bright yellow ochre, or hydrated per oxide of iron, which generally

contains gold in a state of minute division. Sulphuret of iron, (Pyrites,) is another accompanying mineral, which in many mines occurs in considerable quantities. At Morton's mine, (Buckingham,) it is peculiarly abundant, and there, as in other places, generally contains a portion of combined gold. In the Union mine, near the Rappahannock, some of the auriferous veins consist largely of the Pyrites, which here contains so much of the precious metal as to render the extraction of it an object of profit. This Pyrites, in all probability, was at some former period, more generally diffused throughout all the auriferous veins, and by its decomposition, gave rise to the per oxide of iron, with which the quartz is always more or less imbued, while the gold existing in it was deposited in the cells and fissures of the quartz. *Silver* is occasionally found in connexion with the gold, and the sulphurets of copper and lead have been discovered in a few instances in the auriferous rock.

The rocks forming the boundaries of the auriferous veins, vary very much in different localities. Talcose slate, chlorite slate, and a variety of these, abounding in garnets, are the most usual. They are commonly of a soft texture, yielding readily to the blast, and even to the pick or spade sometimes. Instances occur, however, in which the walls of the vein are of such hardness as to greatly increase the expense and difficulty of procuring the ore. Of this a striking example is exhibited in Morton's mine, where the rock is removed with difficulty even by the blasting process, while at Booker's and some other mines, its texture is so rotten that it rather presents the appearance of earth than rock. Veins like the latter, under favourable circumstances, would give rise to what are technically called *deposit mines*, in other words, collections of clay, and sand and gravel, enclosing a portion of gold, all which materials have been removed by the action of torrents or streams from their original position in the vein, to some adjacent ravine or hollow, in which they have been quietly deposited. The rocks adjacent to the quartz are often auriferous, and in some instances have been found as productive as the quartz itself. Of this, several striking instances occur in the mines of Buckingham; and I believe that in many other localities the same condition would be found to exist.

It has already been stated that nearly all the rocks of this region dip steeply to the east, and it is found that the auriferous quartz veins conform in the main to the inclination of the enclosing strata. The quartz is not, however, to be regarded as an interstratified por-

tion of the series, which would imply its contemporaneous origin with the strata.

The form and position of the veins is rarely such as to justify this view. Instead of lying in uniform thickness between the walls of the adjacent rock, and with surfaces of slight irregularity, we find the auriferous veins in most cases very irregular in their forms, at one point having a thickness of several feet, at another very near to the former, contracting so as only to measure a few inches across. Again, in many cases the vein divides, and the separate portions afterwards unite or send off other branches.

The bounding surfaces too, instead of being nearly uniform, as in the strata of the neighbouring rocks, are rough and broken, sending off numerous small veins of quartz into the enclosing strata.

In Morton's mines, the width varies from seven feet to five or six inches. In Booker's the vein forks, thins, and as frequently widens. At the Union mines on the Rappahannock, the breadth varies in some cases from six inches to nearly three feet.

In fact, from the dimensions of the vein at any assumed point, no certain inference can be drawn with regard to its extent at other and remote positions. This irregular structure, while it diminishes confidence in the constancy of a large and fertile vein, at the same time furnishes grounds for continuing the examination and prosecution of one, which by its contraction has become of little or no value, as an enlargement at a small depth beneath, may reveal an abundance of productive rock.

Another fact of some practical importance, and one which, together with those above stated, has a direct bearing upon the question of the origin of the auriferous veins, is this, that although in the main, the dip and direction of the vein conforms with those of the enclosing strata, the correspondence is far from being exact, and in many instances, while the inclination of the neighbouring strata remains unchanged, that of the vein undergoes very striking alteration. At Morton's mine, already referred to, the dip near the surface is about 20° , while at some depth beneath it becomes 45° ; and similar instances of variation might be adduced by reference to other localities.

It would thus appear, that these numerous veins of quartz are not to be regarded as deposits coeval with the regularly stratified rocks among which they are found, since in that case their position and structure would exhibit a like degree of uniformity, but as matter

which, subsequent to the production of the neighbouring rocks, was forcibly injected between them by igneous agencies from beneath, rising in the directions of least resistance, and, therefore, generally, though by no means uniformly, following the places of stratification of the rocks through which they passed. Instead, therefore, of considering them as beds like the adjoining strata, as some writers have done, we would incline to class them among *veins of injection*, of which numerous instances occur in other parts of the globe. We are the more persuaded of the correctness of this view of their origin, from the consideration that throughout all the region in which the quartz veins are found, very peculiar modifications in the structure and composition of the surrounding rocks are invariably to be observed—modifications for which no adequate cause can be found in the other igneous rocks which occasionally occur. In the Blue Ridge, the South-west mountain, and in numerous other lines, it may always be remarked, that wherever the modified rocks occur, indicating an igneous action, more or less intense, which has wrought a change in their structure, and induced new arrangements of the ingredients of the rocks, heavy veins of quartz are sure to lie in their immediate vicinity; while through the body of the rocks themselves, countless minute veins of the same material are seen diverging from the principal mass, and imparting various metamorphic characters to the substances with which they are in contact.

Besides the auriferous veins of the region in which gold occurs, there exist many other veins of quartz agreeing with those which have been found productive in nearly all particulars, save that of containing a valuable proportion of the precious metal. It is highly probable that none of these veins are entirely destitute of gold, and in many instances no doubt the prosecution of the vein would lead to the discovery at other points of it, of an ore sufficiently rich to reward the labour of the extraction. Indeed, it must be looked upon as probable, that the auriferous character, more or less, pervades the quartz veins generally, even as far as their western limit in the Blue Ridge. The striking similarity in the character of them all, and the obvious *contemporaneousness of their origin*, would seem to give great plausibility to this opinion; and if we are to credit the statements of the discovery of gold in the western part of Albemarle, and at one or two other points equally remote from the gold region, as usually defined, we can no longer doubt the propriety of regarding the Blue Ridge as the proper western boundary of the auriferous

rocks. A careful investigation of the numerous large quartz veins ranging along the valley between the South-west mountain and Blue Ridge, becomes in this point of view a matter of great importance; and should the auriferous character be found pervading these veins, as is not improbably the fact, the extent and value of the gold region of the state will scarcely have a parallel upon the globe.

OF THE MICACEOUS AND GARNET SLATES, SILICIOUS SLATE, WHETSTONE BEDS, ROOFING SLATE, STEASCHIST, IRON ORE, &c. OF THE REGION WEST OF THE GNEISS.

In pursuing the line indicated in the section, after leaving the gneiss and hornblende slate, which extend some distance above Columbia on both sides of the James river, the rocks met with are chiefly various kinds of slates and schists, penetrated occasionally by the veins of auriferous quartz already described, and furnishing materials for building and other uses. Analogous beds are also met with in the regions north-east and south-west of that here referred to—ranging through the state in a belt comprehending what is usually termed the gold region, and bounded on its western side by the narrow belt of limestone lying east of the base of the South-west mountain. The descriptions about to be given of these various rocks and other materials, though founded upon an examination of them as they occur in Buckingham, Fluvanna, Louisa, and one or two other counties in the range, will obviously be applicable, with some modifications, to the corresponding beds occurring in other portions of the same belt.

MICACEOUS GARNET SLATE, OR BIRDSEYE MAPLE SLATE.

After leaving the gneiss and hornblende slate a little below Bremo, we come upon heavy vertical beds of a *micaceous slate*, in which are multitudes of half developed garnets, and sometimes crystals of cubical pyrites—giving to the surface of the rock the appearance of numerous knots, around which the fibres of the stone are beautifully curved, so as closely to resemble the shading of the birdseye maple; and hence, in the absence of any specific designation, the one above used may be considered as appropriate at least for ordinary purposes. This rock has the lustre and colour of plumbago, and evidently contains much mica. It possesses considerable hardness, and

may be separated in the quarry in large regular masses—and hence for slabs, pavements, and general building use, may be advantageously employed. At the Buckingham iron works, it has been used in the furnace stack, and has been found to answer well.

The *silicious micaceous slate* occurs a little west of the former, and has a sensible dip to the east, though almost vertical. This rock is of a light yellowish brown colour, contains a small proportion of mica, some felspar, and a large amount of silex, apparently in grains; and in fact, at first view, presents the aspect of some sandstones, though probably more nearly allied to the mica slates than any other known rocks. It may be quarried out in long rectangular prisms, with surfaces nearly as smooth as if formed by the chisel, and from its hardness and durability under exposure, is to be looked upon as a valuable rock. When intensely heated, it becomes glazed on the surface, and is used for the floor of the iron furnace at New Canton.

Associated with these beds, is one containing crystallized garnets in great numbers, and sometimes of exceeding beauty. This rock often contains much chlorite, and presents a general greenish aspect. Large quantities of it have been quarried in building the dam at New Canton, and a portion peculiarly abundant in the garnets, has recently been introduced in the furnace as an auxiliary flux. The large proportion of lime contained in the garnets fitting the rock peculiarly for this purpose, while at the same time it yields a considerable amount of iron.

The *whetstone* beds which occur among the silicious and other slates, also furnish a material of high value. The texture of this stone is exceedingly close and fine; it possesses a proper degree of hardness and great permanency under atmospheric exposure. Its apparently fibrous structure, and the long shape of the masses which are separated in the quarry, give it the appearance of a log of wood, partially decayed. The trial of its qualities as a whetstone, made in Fluvanna, Rockbridge, and the neighbouring counties, amply demonstrate its excellence for this purpose, and in some instances, experienced mechanics have evinced their sense of its superior value by laying aside the Turkey oilstone, and substituting this in its place.

One of the most interesting and valuable of the slaty rocks of this region, is the *roofing slate* which occurs in a thick bed west of the strata which have just been described. This makes its appearance

on both sides of the James river, dipping east at an angle of about 80° with the horizon. In Buckingham, the bed is largely exposed in the neighbourhood of New Canton on Slate river, and the quarry at present wrought by the enterprising owner, Mr. Sims, yields a material which will bear comparison with the better qualities of the imported roofing slate. In texture, density and capacity of resisting atmospheric agents, it can scarcely be excelled by a similar material in any part of the world. This quarry was first opened to procure slate for roofing the capitol; and notwithstanding it has been thus long known, and its value established, but little further use has been made of it, until the activity of the present proprietor has again brought it into notice. The buildings of the University will soon be furnished with a complete covering of slate from this quarry. The bed of slate wrought by Mr. Sims, has an average breadth of sixty yards. The rock splits with great regularity, presenting a smooth surface, and having such strength and flexibility as to admit of being separated by iron wedges into sheets of 100 square feet, and not more than an inch in thickness. There are many other places in the neighbourhood, from which slate of the same kind may be procured, and several small quarries have been opened. Increased facility and cheapness in transporting this valuable article to Richmond and the seaboard, will, no doubt, at some early day bring it into extensive use in our principal towns in that direction, and will render the quarrying and preparation of it a profitable business. During the last year, Mr. Sims brought into a state for the market, six hundred squares of this slate, at twelve dollars per square; and this, with but few hands and very imperfect arrangements.

The *steaschist* or *soapstone* which occurs west of the slate, and may be seen near the mouth of Hardware river, both in Fluvanna and Buckingham, though not as valuable as other beds of a somewhat similar description, to be hereafter described, is nevertheless capable of being very usefully employed. In hearths, jambs and other parts about the chimney, it is found to possess useful qualities, and its texture is such as not only to render it easy of separation in the quarry, but also to make it readily wrought under the chisel. At Bremono it has already been brought into use.

Several veins or beds of *iron ore* exist in Buckingham in the region of the gold veins and slates, and ore of similar description makes its appearance in Fluvanna, Louisa, &c. In the former

county indications of this deposit have been distinctly traced throughout a line of seven miles, and the proprietors of the furnace at New Canton have assured themselves of its continuity for two miles. West of the principal vein is another at the distance of 100 yards: a vein of friable slate dipping east occupying the interval. In the first or principal bed a continuous mass of ore has been uncovered, whose length is about 60 feet, and average breadth 15. As yet no certain opinion exists as to the depth to which it reaches below the surface. This ore is generally embedded in a brownish-yellow ferruginous clay, and fragments lie scattered over the surface in the neighbourhood of the bed. Through a long but narrow belt in Louisa, Fluvanna and Buckingham, and in fact throughout the whole length of the gold region, so called, these surface indications may be traced. The ore is a *hematite*, in irregular masses, sometimes cellular and frequently mammillary. The cells often contain acicular white crystals of great lustre. The colour of the ore varies from a yellowish to a blackish-brown. Its hardness in different localities also differs, and in the immense mass above described, is such as to render blasting necessary. There is some difference as to the proportion of oxide of iron contained in the ore from the two veins near New Canton, and a mixture of both varieties of ore has been advantageously used in the furnace now in successful operation. As early as the revolutionary war iron was manufactured from the Buckingham ore, but until recently this valuable resource has been almost entirely neglected. The limestone on the western edge of the county furnishes the flux employed in the smelting of this ore, which, under the superintendence of Mr. Dean of New Canton, is now conducted on a scale of such extent as to give a weekly product of between 30 and 40 tons of pig metal, much of which is of a superior quality. Ore of precisely the same description is found likewise in the gold region above Fredericksburg, and as in the present instance, in the vicinity of the garnet slate. From the curious association of this ore with the auriferous rocks, it might be expected that in the operations of the furnace a portion of the precious metal would occasionally appear, and accordingly it has been discovered in fine specks in the cinder of the Buckingham works. Magnetic iron ore of a very valuable quality occurs at the base of Willis' mountain in Buckingham, and is found at several other places in corresponding positions.

OF THE LIMESTONE AND MARBLE EAST OF THE SOUTH-WEST AND GREEN
MOUNTAINS.

This belt of rock, represented on the profile as it occurs on the Mechunk creek and in several other places, may be traced with but little interruption through several counties lying in the range there indicated. In proceeding south it appears to become broader, and to be subdivided into several ledges, presenting various aspects in different localities. Wherever examined it has been observed to have an eastern dip, in some places steep, in others gentle. In Albemarle county and at Warminster, its structure approaches to slaty, and its general colour is bluish-gray, frequently veined with white crystallized calcareous spar. On the Mechunk, it lies on slate often of a talcose nature, and its position is such as to render the labour of quarrying comparatively small. At Warminster it is also associated with a talcose schist and a white silicious rock of fine grain and considerable hardness, which has been often mistaken for marble. Along the banks of the James river, from this point to the neighbourhood of Lynchburg, cliffs of the limestone from time to time are seen, sometimes presenting enormous masses of the rock, immediately on the water's edge. The breadth of the belt exposed in this direction is obviously much greater than farther north, and the character of the rock in some localities is such as to render it of the highest value. Near the mouth of Tye river and on the Rockfish, a true marble is found of beautiful whiteness, and of a texture which renders it susceptible of a fine polish, as well as of being readily wrought by the chisel. A few miles from Lynchburg, in Campbell county, a good marble is likewise found, and limestone is abundant in the same neighbourhood. A white and very ponderous rock occurs in contact with the calcareous stratum. This is sulphate of baryta, which from its texture and colour has by some been supposed to be marble. Farther south these beds of limestone of various qualities are known to occur, but have as yet been little examined. The probability is that they are continued throughout the state in the same general line, perhaps spreading out in approaching the borders of North Carolina. In Bedford county, at a point considerably west of the general direction of this belt, marble is said to exist, but no specimen has been procured in the reconnaissance. Minute investigation of the region indicated by the localities above mentioned, and extending entirely across the state, would in

all likelihood be fraught with valuable results. Leaving out of view the marbles to which we have already referred, the beds of limestone existing in this district of the state furnish a resource whose value to the agriculture of a wide tract of country it is beyond our power to calculate. Every bed of limestone developed in such an examination ought to become a source of agricultural improvement to an extensive neighbourhood; and were our farmers once properly impressed with the value of calcareous matter as a manure, especially on the soils of the region now in question, an earnest zeal in the discovery and use of these resources would quickly become general, and an important district of the state would be rescued from unprofitable and disheartening cultivation. Lying adjacent to the slaty and micaceous soils east of the South-west mountain and its prolongation, this belt of limestone furnishes the very material by which under judicious management they may be redeemed from comparative sterility. In Orange, Albemarle, Louisa, Fluvanna, Buckingham, &c., the application of lime procured from this source might with proper arrangements, and the increased facilities which are likely to be afforded to transportation, be made to effect an entire revolution in the agriculture of the country—and even in Goochland, and other counties comparatively remote, similar benefits might be secured at a small additional expense. It is perhaps not generally understood that the slaty and micaceous (or isinglass) soils, such as prevail in the districts referred to, are known to be peculiarly susceptible of improvement from judicious liming. The experience of farmers in Maryland and Pennsylvania has amply shown that this is the case—in those states soils thus characterized are limed to a large extent, and always with the most decided benefit. Experiments made in Albemarle and other places with the lime procured from the limestone beds of which we are now speaking, have demonstrated its value upon the slaty soils in the vicinity, and nothing is wanted to diffuse these benefits extensively through the surrounding country, but a just appreciation of the utility of liming, the introduction of economical and efficient modes of burning the limestone, and the selection of such quarries as from the nature of the rock are calculated to yield a product containing the largest quantity of lime.

A mistaken impression has prevailed, that this limestone always yields a comparatively poor lime; and to this may in part be as-

cribed the little use which has heretofore been made of it, either in agriculture or building.

It will be seen by the following statement of results of analysis, that the amount of carbonate of lime present in these limestones, is in some cases large, and that in no instance can the lime be regarded as a poor one. I have annexed a column, showing the proportion of lime corresponding to 100 parts of the limestone :

	<i>Carb. Lime.</i>	<i>Lime.</i>
100 of blue slaty limestone—Warminster,	81.4	45.5
100 of blue with white veins, do.	88.4	49.5
100 of blue slaty, Mechunk,	83.2	46.6

The extensive exposures of limestone on both sides of the James river, existing in the neighbourhood of Lynchburg, New Market and Warminster, from their very favourable position as regards the facilities of conveyance, are calculated to become peculiarly valuable. Indeed, no position could be found in the state in which lime-burning could be conducted on a larger and more profitable scale. By the introduction of the perpetual kilns now generally used in the extensive lime-burning establishments of the eastern states, much fuel would be saved, and all the lime which the rock is capable of furnishing, would be obtained ; while, by the plan usually pursued, much wood is wasted, and the limestone, particularly of the slaty kind, is but imperfectly calcined. These improvements once adopted, and the better kinds of limestone selected for the kiln, there appears to be no reason why this favoured region may not be able to furnish our eastern towns with lime more cheaply than it can be imported from abroad, at the same time that it is imparting to the surrounding country the benefits of an improved productiveness, and a wiser system of cultivation.

To what has already been said concerning the marble of this region, nothing positive can be added without further investigation. It may, however, be remarked, that from the specimens already seen, particularly the white marble from Tye river, there is reason to hope that this, likewise, may become an object of much value to the district in which it occurs. The Tye river marble, and one or more analogous veins, have all the characters of a statuary marble of fine quality, and should not some peculiarity, as yet unperceived, prevent their application to the purposes of the sculptor, they will no doubt be looked upon as very valuable possessions.

OF THE ROCKS, ORES, SOIL, &C. OF THE REGION WEST OF THE LIMESTONE,
AS FAR AS THE WESTERN FLANK OF THE BLUE RIDGE.

This extensive district of the state comprises a great variety of slates, sandstones, schists and other rocks, almost uniformly dipping east, and in general at a very steep angle. Quartz veins are frequently met with, some of which are believed to be auriferous, though as yet, no profitable mine of the precious metal has been opened in them. Beds of trap occasionally occur, the material of which, from its dark colour and extreme hardness, is usually known by the name of *iron rock*. In some portions of the district, hornblende enters largely into the composition of many of the rocks, while in others, talc and chlorite appear chiefly to abound. But it is important to remark, that amid all the diversities in the mineral character of the strata, a very general conformability of dip may be observed. Looking merely to the mineralogical constitution of the rocks in many localities, an impression of the undoubted primary character of this district would naturally arise. But when a more general exploration of the region discloses the existence of extensive beds of genuine sandstone, and conglomerate rocks frequently in contact with the former, and having the same uniform inclination, we are unable any longer to maintain this view. This opinion, however, would be found incompatible with the results of a more extensive observation of the rocks, of which this region principally consists. It would then be found, that a large portion of its area is occupied by beds of genuine sandstone and conglomerate rocks, and that the chief part of those strata, which at first view might be regarded as crystalline and primary in character, are in reality modified forms of sandstones and conglomerates, which, through intense igneous action, have been made to assume appearances more or less closely resembling those of rocks of the latter description, thus disguising, almost entirely in some cases, the original sedimentary structure by which they would be characterised as not appertaining to a primary formation. It is the existence of this curious class of rocks in many parts of the region in question, as well as the occurrence of occasional beds in which no appearance of the sedimentary origin can be traced, which imparts to the minute geological investigation of this part of the state, so much of scientific

interest, and at the same time renders the task of such an examination laborious and difficult.

Whatever may be our view of the origin of the truly crystalline rocks which occasionally occur throughout this region, numerous sectional examinations, which have been made with the view of solving some of the difficulties connected with its geology, have combined in establishing this interesting conclusion, that by far the largest portion of its surface is occupied by rocks which do *not* belong to the primary system, while they have, at the same time, served to display the modifying effects of igneous agents, as manifested in the changed structure of many of these rocks, on a scale of wonderful variety and extent.

Early in the present report, allusion was made to the prevailing errors on the subject of the true geological character of this region, inclusive of the Blue Ridge; and enough has already been stated in regard to the structure of the region, to satisfy the enlightened geologist of the entire impropriety of the designation of primary which it has heretofore uniformly received. The further particulars about to be given relative to some of its rocks, chiefly those of economical value, will serve still more clearly to evince the inaccuracy which has hitherto prevailed with regard to the limits of the great geological subdivisions of the state, as well as to display the practically valuable results which are linked with an investigation which at first view appears to be purely scientific in its character.

The rocks of the South-west mountain and its prolongations, and of the country within a few miles on either side, will first be described, after which some account will be given of those lying more to the west, and in particular of some portions of the Blue Ridge.

Pursuing the line indicated in the profile, after leaving the bed of limestone, already referred to, we meet with slates and schists in some places of a micaceous and talcose, and in others of a silicious nature, and so friable as to be of but little use in building; comprising occasional beds of a denser texture, and more resembling roofing slate. This brings us to the greenish and dark blue argillaceous sandstone of which Carter's mountain, as well as much of the region on its eastern and western flanks, principally consists. Beds of gray and yellow sandstone occasionally present themselves among the darker rock, and these are uniformly of a coarser texture, and in many cases are rapidly decomposed by exposure to the air and weather. Quarries of the dark greenish and bluish rock have

been opened in many places, and furnish a material for building which can hardly be excelled either for strength or permanency under exposure. Much of this rock, however, is so hard as to prove difficult of separation in the quarry. This is remarkably the case with the green variety, which occurs very abundantly for a mile or two east of Meriwether's bridge on the Rivanna. This rock bears the strongest marks of intense igneous action in its flinty hardness, and in the large quantity of green epidote which has been developed throughout its structure. It is, moreover, always intersected by veins of quartz, so that it would be difficult to find a mass of considerable size, in which many of these veins would not be visible. It is further to be remarked, that always in the vicinity of these quartz veins, the rock is hardest, and displays the largest portion of the green colouring material. All these facts would seem clearly to point to the quartz, as having been directly concerned in the various modifications which the rock has obviously undergone. In further illustration of this view, it may be added, that often in the immediate neighbourhood of the veins of this material, asbestos, iron pyrites and other minerals occur, which are known to be thus developed in various rocks by veins of intensely heated matter injected into them in a state of fusion. At Meriwether's bridge and in many other localities along the range, the greenish-blue rock is studded with black and greenish spots, indicating an incipient crystallization, and clearly referable as the geologist would at once perceive, to the agency of which we have spoken. Here, as well as in all places where similar evidences of igneous action can be traced, the dip of the rock becomes confused in consequence of the occurrence of numerous cross joints, such as are often produced in stratified rocks by an action of this nature.

The gray and yellowish-red sandstone, occurring in beds sometimes of considerable breadth, and traversing the country in the general range of rocks to a considerable distance, are found in many places to furnish quarries of very valuable building material. Such of these beds as are intersected by frequent veins of quartz, are found to be by far the hardest and most valuable. In the same bed, examined at points some distance asunder, a great difference in the hardness and consequent value of the material, may frequently be observed. Thus, the bed which on the eastern flank of Peter's mountain, near Gordonsville, yields a building stone which comes from the quarry in long quadrangular blocks of great hardness and

durability, presents at the distance of several miles to the south a crumbling mass, whose value consists in its being useful as a substitute for sand, or furnishing a good material for the manufacture of fire bricks. It may, therefore, be found a guide *of some value* in the selection of rock for flags or building purposes, to choose such as, lying in the vicinity of a heavy vein of quartz, and intersected by smaller ones throughout its substance, is likely to possess the combined advantages of great hardness and durability, and a comparative facility in being quarried, in virtue of the cross joints by which it most generally and spontaneously divides itself.

In addition to the rocks here described as occurring particularly in the South-west mountain and its vicinity, various others are presented both to the south and north of the localities to which the profile may be considered as referring. Thus, in Orange and in Nelson and Amherst counties, as well as in the neighbourhood of Scottsville, in Albemarle, and interruptedly in many other places in the same general range, a very interesting rock is seen, consisting of fragments sometimes angular, sometimes more or less water worn, cemented together by particles of sand, and occasionally a small admixture of carbonate of lime. This singular conglomerate has evidently been in part derived from the greenish-blue rock previously described, with which its larger pebbles or fragments are obviously identical—and in part from the sandstones and occasionally the limestones of this region. It is in fact the representative, in this portion of the state, of the Potomac marble, and some of it when polished would present a surface of equal variety and beauty. The occurrence of this rock, as here described, obviously marks an epoch of violent action, in which the neighbouring strata, of which it may be considered as embodying the ruins, were broken into fragments, and these subjected for some time to the rounding agency of water, at the bottom of which the coarser and the finer sediments were at length consolidated into rock. A curious fact, for the first time observed by my brother, Professor H. D. Rogers, would seem to show, that in the composition of the Potomac marble, fragments of limestone may be seen, referable to no nearer source than the great valley west of the Blue Ridge. In some of the columns in the senate chamber at Washington, which by their beautiful polish enable the observer as it were to look into many of the rocky fragments of which they are composed, he detected distinct impressions

of Encrini, a fossil remain abounding in the bed of limestone near the western flank of the Blue Ridge, and for which we might in vain look in the limestone previously described as skirting the eastern flank of the South-west mountain. This curious discovery will at once indicate the extent of the violent agencies preceding the formation of this rock, and of the conglomerate which we have regarded as its equivalent.

In the same region likewise, beds of genuine red sandstone occur, sometimes of a fine and sometimes of a very coarse grain. This and a variety of red slate are the chief rocks to be met with between Warminster and the Folly. Similar beds are to be seen in many places in Orange and other counties in corresponding positions. In Amherst, near the Stonewall mills, strata of coarse conglomerate occur, in which the pebbles have sometimes a diameter of half an inch.

Near Lynchburg, a very beautiful bluish-gray sandstone is largely quarried, and in the same neighbourhood very extensive exposures of various sedimentary rocks may be seen. In nearly all the localities which have been described, the dip of the rocks is east. At the latter place, however, a very superb exposure of a silicious and talcose schist is presented on the river bank immediately opposite the town, exhibiting the feature so strikingly seen among the sandstones of the North mountain—that of an arch or great bend in the strata, showing the eastern and western dips at its opposite extremities.

On the western declivity of the Green mountain, beds of steatitic rock occur, furnishing a soapstone which in all respects compares advantageously with that now generally in use. A quarry of this rock has been opened near the residence of Tucker Coles, Esq. from which slabs and jambs for fireplaces have been procured. The colour of the rock is a grayish and sometimes greenish-blue, with a somewhat marbled appearance. Its texture is fine, and with sufficient firmness for any purpose to which it may be applied. It is capable of being cut and planed with great facility. With the exception of some of the finer kinds quarried in Vermont, there is probably no soapstone used in this country which combines the valuable characteristics of this species of rock in a higher degree. The recent introduction of anthracite as a fuel in some of our cities, and the probability that ere long the semi-bituminous and anthracite coals of the western ridges of our valley will also be similarly ap-

plied, impart additional interest to the facts here stated, and render it highly probable that this rock will at no remote day be brought into extensive use. In the same neighbourhood are found sandstones and schists, all preserving the same general direction and dipping to the east.

Throughout the South-west mountain and its prolongations, but especially on the Buffalo ridge, *micaceous and magnetic iron ore* occur. In the neighbourhood of Stonewall mills, and near the Buffalo ridge spring, these ores are peculiarly abundant. They are also met with largely in the vicinity of the Folly. Hematite containing some manganese is seen also apparently in veins in a slaty rock at Reuben Carver's, near the above named mills, and has been supposed by some to be an ore of silver. The micaceous oxide is generally blended more or less intimately with the substance of a talcose and silicious schist, and appears to exist in beds of considerable breadth amid these rocks. Hitherto, little value appears to have been attached to the magnetic oxide or oxidulated iron ore which is thus abundant throughout this region; and yet, judging by the experience of other countries where this ore is smelted in great quantities, there can be but little doubt that under a judicious system of operating it might be found a highly valuable material for the manufacture of iron. In the highlands of New Jersey, so noted for the quality and amount of their forged as well as cast iron, an ore of precisely the same character is used, and the difficulties in smelting, which appear to have deterred our iron masters from its employment, are completely overcome.

In many places, within the belt of which we are now treating, beds of rock occur, containing green carbonate, sometimes associated with a little sulphuret of copper. At the Folly in Amherst, numerous openings may be seen from which the cupreous rock was formerly obtained. The amount of copper present in such of the specimens from this locality as have been examined, though considerable, is not such as promises any high degree of value in the mass. It is, however, to be remarked, that no positive opinion on this subject can be formed without much minute examination of all the places in which this rock exists, as well as a number of analyses to determine the proportion of copper which it contains. No distinct vein or bed of copper ore is indicated, but rather an impregnation of the talcose rock of the neighbourhood, more or less strongly with

the above mentioned compounds of that metal. In some of these places the manufacture of copper has been attempted, but without the success that would justify a prosecution of the enterprise. In Orange, Taylor's copper mine, though opened with high expectations of profit, has been long abandoned. In the neighbourhood of the Folly, judging from the number and extent of the excavations which are seen, we would be led to infer that at the time when they were made great value was attached to the material which they furnished; and if the traditions of the country in regard to the operations of Colonel Chissel in this region prior to the revolutionary war, may be received as authentic, that singular and mysterious personage found in the products of these mines or pits a rich reward for all the labour and expense which he appears to have bestowed in working them. It would seem that the cupreous rock was not smelted by him, but merely ground in a mill, some vestiges of which still remain, and then packed up and sent to England.

Similar bands of cupreous rock occur in Campbell county on Beaver creek, about two miles from Ross' furnace, and also in the lower end of the county. Pits like those at the Folly have likewise been opened on the land of Mr. Walker, near the James river in Buckingham.

Among other interesting minerals occurring in this region are beds of chloritic steatite and chlorite slate near the Variety mills, Nelson county; galena or sulphuret of lead in veins; in quartz at Rennet-bag creek, Franklin county; sulphate of baryta in numerous localities; sulphuret of iron in cubical and other forms, very frequent; plumbago in considerable masses in Buckingham and Amherst; brown oxide of titanium in the neighbourhood of Lynchburg.

Many parts of the region of which we have been speaking, as for instance in the vicinity of Lynchburg, the Buffaloe ridge and the Folly, are likely to form highly interesting localities to the mineralogist, from the variety and character of the minerals they furnish; and there is little doubt that interesting developements, in a practical as well as scientific point of view, will result from the minute exploration of these and other districts throughout this portion of the state.

What has now been said in relation to the rocks of the Southwest mountain and its flanks, will with but little modification be

found applicable in a general way to the rocks of the Blue Ridge and the intervening country. Beds of dark green rock containing hornblende, are occasionally presented. Slates, schists, sandstones and coarse conglomerates, sometimes but little changed, at others modified in various degrees, succeed each other as we travel west. From the South-west mountain, and even in the Blue Ridge, the beds of rock exhibit the same features and the same general dip to the east. In the Ragged mountain the rock usually occurring is a coarse conglomerate or sandstone containing mica, and more or less modified, so as to exhibit a structure partly crystalline. In a direction north-west from Charlottesville, a conglomerate containing large pebbles of angular quartz occurs, and in the same vicinity fine-grained yellowish sandstone.

Most of these rocks contain a large proportion of felspar, so as in some cases when disintegrated, to have many of the characters of a kaolin. A bed of this species exposed near the University, has been found by Professor Emmet to furnish a material susceptible of various useful applications. When baked at a very high temperature, this rock may be made into hones of a very fine and sharp texture. It admits of being readily carved or turned into crucibles and other useful implements, for which it is well fitted, by its power of withstanding heat; and for the same reason it forms a very valuable fire brick.

With the view of illustrating the structure of the *Blue Ridge*, the following descriptive list is presented of the rocks which occur at Turk's gap, beginning at the western, and proceeding to the eastern base of the mountain. A series of beds in the main analogous to those about to be described, may be observed at Rockfish and Brown's gap, and other points which have been examined in the course of the reconnoissance.

In the profile all these rocks are exhibited dipping steeply to the east, which is their position as observed at Turk's gap. But at the Balcony falls, where the exposure of rock is extremely grand and interesting, the beds on the western flank of the ridge are seen dipping west; east of this they are seen rolling and arching in a manner to indicate violent disturbing action, and at length they assume the ordinary eastern dip. At this place the sandstones of the western base form beds of great thickness. They are for the most part grayish, but some layers of a dark brown colour may be seen among them.

Rocks of the Blue Ridge commencing at the western base at Turk's Gap.

1. A light gray moderately fine-grained sandstone, met with near the base of the gap, and extends up a third of the way to the top. Dip steep to the S. E.

2. A finer closer-grained rather bluish variety of the same, overlying the former.

3. A lead coloured argillaceous slate, slightly talcose, occupying another third of the western side of the mountain.

4. A dark-purplish gray and extremely close-textured indurated sandstone, bearing evident marks of igneous action. This bed is not thick.

5. A schistose gray sandstone, rather argillaceous, with minute specks of black sand, and little grains, the size of a pea of transparent amethystine quartz.

6. A greenish-gray chloritic looking schistose sandstone.

7. A fine-grained dark bluish-green argillaceous sandstone, full of incipient crystallization in small vitreous specks, the size of mustard seed. These specks are small amygdals, the exterior being a semi-transparent yellowish-green matter like quartz, the centre being black and granular.

8. An argillaceous sandstone like the former, but containing more crystalline specks, some of which are of an opaque pinkish-white.

9. Like the two former, the specks being better devolved, some of these green and transparent, others pinkish-white, looking like analcime.

10. A very coarse, extremely hard sandstone, round grains of semi-transparent quartz, in a coarse argillo-silicious paste, evidently much indurated.

11. A coarse-grained purple sandstone; the rounded gravel of pink or amethyst coloured quartz, united by a dark paste.

12. A gray purplish porphyritic looking conglomerate, of very heterogeneous composition, green, red, white, &c. some felspar, much quartz, and to appearance the matter of the green sandstones of the ridge.

13. A similar compound approaching to a brick red, angular

pebbles of felspar and rounded ones of quartz, &c. in a deep red paste. The four last specimens belong to the S. E. slope of the ridge.

14. A white, rather loose and coarse sandstone, the grains united chiefly by felspar.

15. A coarse sandstone, with rather angular pebbles of quartz and felspar scattered through a paste very similar to the mass of a greenish chloritic sandstone.

16. A very light lemon-green epidotic sandstone, with small specks of quartz and veins or patches of asbestos.

17. A very heterogeneous conglomerate, in aspect somewhat like the Potomac marble, and identical with the conglomerate before described as occurring in the vicinity of the S. W. mountain, &c. the larger pebbles identical with No. 6.

18. A compact, close-grained purplish-gray sandstone, greatly altered, having kernels of epidote, and quartz, and deep red blotches, making it look like heliotrope.

19. Similar to 7, but destitute of the specks.

20. At the eastern base of the ridge, slaty sandstones of a gray colour.

In presenting the above account of the series of rocks in this portion of the Blue Ridge, I do not wish it to be inferred, that precisely the same beds in the same order will everywhere be found. Observation has shown, that in different parts of the range, the rocks vary somewhat in their character, that while in some places the sandstones are greatly indurated, and filled with various minerals, apparently developed by intense heat; in others, they are comparatively unaltered, though in all the localities yet visited, some of the beds exhibit great induration from this cause. We are, however, to take this descriptive list as representing the important peculiarities of the rocks of the Blue Ridge, and we have preferred thus describing them in some detail in the order in which they occur, to attempting to name them according to any supposed or fancied analogies they may bear to rocks, which are found in the old world. Such analogies are very vague, and in this as in many other instances in the geology of our country, are calculated to give permanency to error and check a proper spirit of investigation. In the true spirit of his science, the enlightened geologist has learned to distrust the generalizations which would always seek analogues to

the rocks of one side of the globe, in those of the other, and will, therefore, prefer a description of the object itself to any appellation to which, from its supposed resemblances, it might be thought entitled.

From the list above given, it will at once appear, that, there is no material difference between the rocks of the Blue Ridge and those of the South-west mountain and the intervening country, and that they seem in the main to be distinctly referable to a sedimentary origin.

From the above view of the general structure of the ridge, we may derive a suggestion of some importance in connexion with plans of internal improvement projected in the state, which is, that the dense and impracticable character of many of the rocks above described,—for instance, those from six to twelve,—forbids any attempt at tunnelling the mountain, at least in those places which have been examined, and evinces the necessity, whenever such a plan shall be proposed in reference to other parts of the ridge, of first ascertaining whether it does not there also include near its axis materials equally unfavourable to operations of this kind.

The *soils* of the region from the Blue Ridge, east as far as the limestone, are in many places of a deep red or chocolate colour, while in others they present either a grayish or yellowish hue. Those of the former kind are usually regarded as most fertile, and chiefly give value to the lands of Albemarle, Amherst, and other counties in this part of the state. In accounting for these striking peculiarities of colour and agricultural properties of the soils in question, it has been usual to regard them as resulting from the hornblende, frequently met with in the rocks of this region, which by its iron would give colour, and by its lime impart fertility, to the land. There is, however, but a small portion of this deeply coloured soil traceable to a decomposing rock of the description mentioned, and by far the largest part of the land thus tinged had been produced by the disintegration of the dark greenish-blue sandstone, such as occurs so abundantly in the South-west mountain. Much of the richest and darkest red soil of Amherst and Albemarle has no hornblende in its neighbourhood, while beneath and mingled with the soil, fragments of the sandstone above referred to, may be seen in all the gradations of condition, from the hard greenish rock recently separated from the mass, to the crumbling half-earthly and deeply

reddened lump, ready to be reduced by the next winter's frost into productive soil. By analysis recently made, I find that both the greenish sandstone and the resulting soil, contain a sensible quantity, sometimes two per cent. of lime. Should this be found by further research to be an invariable ingredient of these valuable red soils, we might, perhaps, be authorised in ascribing their productive character, at least in part, to its presence; and we would to a certain extent be enabled to compare these soils with one another in agricultural value, by chemically examining them for lime.

Portions of the red soil in Nelson and Amherst, arising from the decomposition of a red sandstone and conglomerate before described, contain lime in a still more considerable proportion. The rocks from which they are procured, in some instances, present upwards of six per cent. of carbonate of lime. A specimen recently examined, yielded me in one hundred grains, precisely 6.75 grains of this substance.

OF THE VALLEY OF VIRGINIA.

The sectional line crossing this region, to which the profile refers, commences at a distance of two or three miles from the western base of the Blue Ridge, this being the position at which the rocks of the valley first become apparent. Of the character of the beds comprised in this interval, we have no data enabling us to speak with certainty, inasmuch as the fragments of sandstone derived from the broken strata of that range, piled upon the subjacent beds of the valley, entirely conceal them from observation. At other points along the eastern edge of the valley, the interval thus hidden from examination is not so wide, but in no place hitherto observed have the rocks of the valley and those of the Blue Ridge been seen in contact. This, as yet, undetermined ground, is therefore represented on the profile by a blank, at the western boundary of which the valley rocks, where first observed, are represented as commencing. Future observations throughout this curious district are indispensable to an understanding of the true relation existing between the formations bounding it on either side, and will accordingly present subjects of geological, and even of practical interest in the prosecution of more detailed research.

As the profile indicates, beds of slate and limestone, in alternate

order and dipping almost uniformly to the east, occupy nearly all the space west from this to the commencement of the sandstones of the ridges subordinate to the North mountain. Layers of a very silicious limestone, and bands of sandstone, occasionally occur. Between Harper's Ferry and Winchester, two alternations of the slate and limestone may be observed; the most eastern bed, composed of slate, dipping east at an angle of 30° into the valley of the Shenandoah, succeeded by a broad range of limestone of a dark blue aspect, and but little veined, dipping in the same direction, next to which is another bed of slate followed by one of limestone, both dipping as before.

Approaching the northern extremity of the Massanutten mountain, the belt of limestone presents interesting peculiarities, some of which may with great probability be referred to the proximity of that lofty range. It is here traversed by large veins of calcareous spar, in general running across the direction of the edges at a considerable angle, and it is thrown off from the flank of the mountain with a reversed or western dip. The veined condition of the rock distinctly pointing to a period during which it was subjected to violent actions, cleaving it into countless fissures, subsequently filled by infiltration with the pure material of the rock, taken in connexion with its inverted dip along the mountain flank, gives great probability to the idea that the upheave of this range took place subsequently to the formation of the rocks of the valley, and that thus the fissured structure and changed direction of the adjacent rocks, were merely consequences of the elevation of this enormous mass. In connexion with this curious point of inquiry, the investigation of the materials and structure prevailing in the Massanutten mountain, cannot fail to prove interesting to the geology of the state. Such an examination, moreover, promises more than any other to reveal the geological relations of the valley with the regions bounding it on either side, and thus to solve some of the most curious problems with which the student of our geology at present cannot fail to be embarrassed.

In the valleys of this mountain slates and limestones occur, and rumour intimates that *coal* even has been found. Beds of a coarse conglomerate of very peculiar structure, constitute an important portion of its mass, and furnish the material of mill-stones, now much in use. Limestone is said to occur on the summit of the Peaked

mountain, a part of the Massanutten, and it is not improbably the fact.

Should coal ever be discovered in this region, it will probably be *anthracite*; and certainly the character of the rocks of the Massanutten, so far as they have yet been examined, is not *adverse*, if it be not favourable, to the opinion that the search for this mineral might be attended with success.

In passing some distance south and west of Strasburg, the strata resume their former eastern dip, having here apparently been too remote from the mountain, to experience much violent dislocation or change of direction when it arose.

In the counties of Rockingham, Augusta and Rockbridge, limestone and slates, alternate as before; the former in some places passing into veined varieties, and occasionally presenting bands and beds of *marble* of a good quality. A roll in the strata, or some change and irregularity in the dip, will usually be found to attend the veined or marbled varieties of the limestone, and may be looked upon as a useful guide in the search for quarries of the ornamental rock. A bed or beds of hydraulic limestone, runs along the valley not far from its eastern side, to an extent not yet determined. In the neighbourhood of Shepherdstown, this rock has been quarried, and found highly valuable in the formation of water cement. A similar limestone appears on the North river, about nine miles from the Balcony falls, and at some intermediate points, but as yet no analysis has been made of the rocks from these localities, and but imperfect trials have been made of the lime obtained from them. It would appear that a limestone of analogous character is found also in Botetourt county, and even further south.

An analysis of the hydraulic limestone from the neighbourhood of Shepherdstown, shows it to contain nearly a third its weight of alumina, while the common limestone of the vicinity, and indeed of the Valley generally, contains but a small proportion of this earth. A mere analysis, however, is not always sufficient to determine the value of the material, for the purposes of a cement; and should, therefore, be accompanied with direct trials calculated to test its qualities in this respect. Attention is only beginning to be directed to this subject, which is one to which, from the character of some of our great works of improvement, a minute geological and chemical investigation might be very beneficially directed.

It is curious to remark, that in Pennsylvania and New Jersey, limestone of this description occurs in precisely the same relation to the other rocks as in the region we are now describing; and from its well known and fairly tested value, as employed in those states, we may look with confidence to the early discovery of valuable beds of it in numerous parts of the corresponding region in Virginia. Fortunately for its use too, the anthracite of the North mountain is of that description of coal which has been found by far the most suitable fuel in preparing it for a cement.

The existence of *fossiliferous bands*, in some of the limestones of the valley, is an interesting geological fact, of which no notice appears hitherto to have been taken by those who have professed to explore the country with scientific objects. Near Strasburg, on Cedar Creek, and other points around, the rock displays great numbers of impressions, of *enerini*, &c. and some trilobites. At Mount Meridian mills, in Rockingham, organic limestone likewise occurs, and what is most remarkable as having hitherto escaped attention, the limestone of Weyer's cave and the vicinity occasionally exhibits similar impressions of a very interesting and peculiar character. Farther west, in the neighbourhood of Mossy creek, fossils occur in a more silicious variety of limestone, and I have in my possession a fine specimen of *fucus* from this locality. Such bands of fossiliferous rock seem to be of more frequent occurrence farther south, and are quite common in Botetourt and Montgomery counties.

The importance of the valley *limestones*, as furnishing a powerful lime for agricultural and various other uses, cannot be too highly appreciated; indeed, it is rather matter for surprise, that the agriculture of this region has hitherto been suffered to reap so little general benefit from this great source of improvement completely within its reach. As yet the application of lime to the lands in this part of the state is in a great degree restricted to particular neighbourhoods, while (in many extensive districts) through the want of experience, and of knowledge respecting its employment elsewhere, the efficacy of lime as a manure, is regarded with a degree of doubt sometimes amounting to entire disbelief. An impression that the soils of this country are already sufficiently impregnated with calcareous matter, in consequence of the proximity of the limestone rock which occasionally rises to the surface in the fields, seems more than any

other circumstance, to have led to the erroneous notion that lime could be of no benefit to the soil. It must therefore be regarded as a fact likely to affect the opinions and practice of persons entertaining these views, that in a great many cases, the soils of the valley contain little or no calcareous matter, even when taken from the immediate vicinity of a limestone rock—a fact which has also been observed by my brother and myself, in regard to many of the soils in the corresponding region in Pennsylvania and New Jersey. In the valley of the former state, lime has long been in extensive use, and is well known to have been the means of imparting rich productiveness to many wide districts in the limestone country which were formerly regarded as of little value, while in the small belt of corresponding character in New Jersey, a soil of almost sterile worthlessness has by the same means been imbued with an extraordinary degree of fertility. Experience thus ample and satisfactory, under circumstances which can leave no doubt as to the applicability of the results to the valley of our own state, will, it may be confidently hoped, impress our farmers in that region universally with the importance of availing themselves of the invaluable resource which is everywhere spread around them, and of thus removing the imputation of indifference to improved modes of agriculture, which the active enterprise of other regions has already proved to be of great permanent advantage.

The value of the limestones of our valley, with a view to this most important of all their applications, may be judged of by the results of several analyses recently made, from which it appears, that in most cases, the carb. of lime exceeds 80 per cent., and in some is largely over 90 per cent. of the whole mass. A series of analyses, giving the composition of all the varieties of the rock in numerous localities in each county through the valley, would subserve one of the important interests of this region, by enabling the farmers to infer what ought to be the proportion of pure lime present in the product of the kiln in each locality.

Another valuable material hitherto neglected in this region, is the *travertine* or deposit marl which exists in some places in large quantities. In Jefferson and Frederick, this chalky deposit forms beds of considerable thickness, mingled with but little extraneous matter. In Rockbridge, nearly all the streams that empty into the South river, flow over a material of the same nature; and in fact

no extensive district of the valley will be found wanting in this deposit. It is in truth a precipitation of the calcareous matter from the limestone waters, which are universal throughout this region, and must therefore be looked for as occurring in most neighbourhoods where springs thus impregnated are of general occurrence. Now, it is important to be known, that from this substance a lime of very superior quality may be made, and that judging by the value attached in the market to that from the travertine of Caledonia in New York, the burning of this material in some of our localities might be attended with very considerable profit; at all events its utility in agriculture added to the facility with which in some places the deposit may be obtained, (no quarrying being necessary to separate it from the mass,) would render it an advantageous substitute for the limestone of the same neighbourhood. Moreover, it should be remembered, that in the more friable or powdery state in which much of it is found, it may, as in Europe, be very beneficially applied as a marl without being burnt. The immense improvement which eastern Virginia has derived and is now receiving from the calcareous manures, must render any illustration of the effects of this substance altogether superfluous, when it is understood that in composition it cannot be distinguished from the better qualities of the pulverulent marls, of which analyses have been given in the early part of this report. Independent of which, its value has been unequivocally tested in other countries, where it has been found to have the most decided ameliorating effects upon land to which it is properly applied.

From what has been said respecting many of the soils of the valley, it is not to be inferred that they are all devoid of calcareous matter, or indeed that this ingredient is not very often present in some proportion, but rather that in few or no instances does it exist in the soil to such an extent as to interfere with the advantageous application of lime or unburnt calcareous manures; and under these views, I would urge upon those who are particularly interested in the success of agriculture in the valley the benefits to be anticipated from the diligent use of the various resources so abundant and accessible throughout this portion of the state.

The *iron ore* of the valley constitutes another of its most valuable possessions. This, although manufactured into iron in numerous places, has as yet been the subject of no systematic geological and

chemical examination, further than the mere determination of its general features, and some of its qualities in the furnace. An examination of the composition of all the principal varieties now in use, as well as the determination of the relations of the deposits geologically with the rocks among which it is found, would furnish matters of inquiry, whose practical bearing upon a valuable branch of industry in this region, will be promptly and fully recognised by all who are interested in its success. For, although the tact of the operator, in this as in almost every department of the arts, is necessary to the profitable pursuit of the manufacture, those engaged in the smelting of iron have long been sensible, at least in other countries, of the high importance of such suggestions as are furnished by a chemical examination of the ores upon which they operate, and a geological investigation of the positions in which the beds of ore occur. The ores almost exclusively in use are hematites of various aspects, known under the names of honeycomb and pipe ores—many of which yield a metal of the very finest character. The facility of smelting, as well as the quality and amount of product, varies of course with the description of ore employed—and from the want of such knowledge as has been just referred to, the difficulties of the process in some places have almost put a stop to the operations of the furnace.

A new interest attaches to this branch of industry, at least in some portions of the valley, from the recent discovery in the immediate neighbourhood of the iron, of beds of a semi-bituminous dry coal, which, if we may trust to the indications of its composition, may hereafter be employed as a most efficient and profitable substitute for charcoal in the furnace. Of this coal, as it occurs in the Catwaba mountain, and at other points in the valley, but little as yet is known; but should the hopes excited by analyses which I have recently made of specimens from the former locality, prove to be well founded, a new impulse will be given to the iron manufacture in that district of the state, and rich rewards be proffered to the enterprise of capitalists who engage in it.

Of the various objects interesting to the mineralogist, which are to be found in this region, but little definite knowledge has yet been attained. We may, however, mention carbonate and sulphate of baryta, octahedral and dodecaedral sulphuret of iron, pellucid quartz and crystallized selenite, as occurring more or less abundantly in

different places. Of the lead ore, gypsum, &c. of the south-west, we will speak hereafter.

The numerous extensive caves occurring in this region, form one of its most curious and interesting features, and serve to illustrate some of those geological and chemical agencies to which allusion has been made in explaining certain facts connected with formations in other parts of the state. Thus, in the rich and variegated crystalline deposits and concretions, which render some of the caves objects of so much curiosity to the visitor—the solvent action of water upon the various kinds of rocks composed of carbonate of lime, and the ready tendency of the dissolved matter to separate in a pure and crystallized condition, are both beautifully displayed, while the rounded surfaces of the rocks within the caves, and the generally curved contour of the various apartments, give evidence of the wearing, as well as the dissolving energy of subterranean streams. Usually some *disturbance* of the rocky strata will be seen in and around these caves; and in the various fissures and deep clefts naturally accompanying such dislocations of the strata, we are furnished with a ready explanation of the means by which the agent that has thus scooped them out, originally obtained access to the surface of the rock.

OF THE NORTH MOUNTAIN AND ALLEGHANY REGION.

The numerous ranges of mountains which lie beyond the general limits of the valley, present several features of great practical, as well as scientific interest. In the profile view, a section of the Little North mountain, as presented west of Mossy creek in Rockingham, terminates the line of observation first examined; and the profile is resumed at a point farther south, in a direction from Covington across the Great North mountain into Rockbridge. The lesser ranges of mountains which first interrupt the general undulating surface of the valley, known by the various names of Little North mountain, Catawba mountain, &c., indicate the commencement of a series of rocks entirely distinct from those occurring in the valley, being composed of sandstones and conglomerates, and of shales subordinate to the veins of anthracite and semi-bituminous coal, which here discover themselves. The dip of these, so far as observed during the reconnoissance, is somewhat steeply west, as re-

presented in the profile. A similar direction of the strata is also seen in the range of the North mountain in Rockbridge and elsewhere, but as exhibited in the section of Brown's ridge and the Mill mountain, the dip is east. The rocks composing the North mountain at the place represented in the section, are chiefly sandstones of different hues and textures, with a reddish shale appearing towards the eastern base. Ascending by the eastern side, after passing these shales, we meet with red and gray sandstones; then deep red sandstone with occasional seams of a shale interposed, to near the summit, where we find a heavy stratum of white pinkish sandstone exposing an extensive bared surface, which dips N. W. On the western side following the winding of the spurs, the pinkish variety of rock is succeeded by gray, and thence tracing the mountain to its base, the red and gray varieties appear with changing dip, such as would be explained by the structure indicated in the profile view of this side of the mountain. Pursuing a western course, we find slate dipping to the west for some distance from the flank of the mountain, but assuming an eastern dip as we approach the base of Brown's ridge, where a bed of limestone, with a correspondent dip occurs, after which we come upon the gray and reddish sandstones composing that ridge, which also dip in the same direction.

There being no reason for doubting the identity of the rocks in the North mountain and Brown's ridge, we are led to infer, that immediately at the base of the former there exists a western dipping limestone similar to that with eastern dip at the base of the ridge, but not having detected it in consequence of its being concealed by the fragments of rock collected there, it is not indicated in the figure. The series of rocks thus far, commencing with that which in the horizontal disposition, must have been the lowest, would, therefore, be sandstone, limestone, slate; and this order we shall find prevailing for some distance farther west. The sandstones of Mill mountain, like those of Brown's ridge, dip east, and are separated from the former by an intervening valley of slate, the western portion of which is seen dipping in conformity with the rocks of the Mill mountain, but in the eastern part no rocks *in situ* could be seen on account of the mass of fragments by which they were covered up. From the precipitous escarpments of the two ridges here described, the apparent identity of those rocks of which they consist, and other striking circumstances in the features of the valley, there can be but little

doubt that lines of fault, giving to the strata of sandstone, limestone and slate, originally horizontal, an *eschellon* position, have occasioned this repetition of the rocks of the ridge in the Mill mountain, preserving their dip in the same direction; or more familiarly speaking, these two ridges were thrown up from their horizontal position under such an action of the dislocating force as not to elevate the rock on the western side of each; and, therefore, not to present any strata having a counter or western dip. To present this principle, which is familiar to geologists, in another point of view, the rocks of the Mill, Brown, and North mountain, being rocks of sediment, and having, therefore, been originally horizontal, or nearly so, formed one continuous bed, the sandstone lying beneath, the limestone next, and the slate upon the surface. The disturbing force throwing up the sandstones of the North mountain, gave them a western dip, while other forces dislocating the strata to the west, gave them the parallel but not continuous positions which they now display. Instances of this kind of disturbance are among the most usual in geology, and would readily be inferred by those versed in the subject to have occurred at the points here described, by a simple view of the profile itself.

But it is thought that the explanation above given will aid the general reader, for whom the report is chiefly intended, in understanding the delineation of this portion of our line. West of the Mill mountain to near the base of the Warm Spring mountain, we pass over slates occasionally exposing the subjacent bed of limestone, but throughout this valley scarcely a glimpse of the sandstone which lies still lower can be had. At Bratton's Ridge, the limestone comes boldly out with an eastern dip, and at some distance beyond, a turn not delineated having occurred in the strata, the slate is seen dipping in the opposite direction. This brings us to the little valley of the Millboro' Sulphur spring, which here issues from the pyritous slate—and now the slate is found dipping to the east until another change brings up the limestone into view near the Blowing cave, and the dip becomes west again; after which, with several rolls or undulations as seen in the Cow Pasture hills, it settles into an eastern dip, which continues to the boundary of the slate near the base of the Warm Spring mountain. Here limestone occurs dipping with the slate, and this brings us upon the debris piled upon the skirts of this lofty range. As the structure of the Warm Spring valley will re-

ceive an especial notice, I will defer any further description of the profile for the present.

The region to which the portion of the profile just described refers, abounds in objects of practical as well as curious interest.

The *coals* of the Little North mountain, Catawba mountain, &c. are among the most prominent of these in an economical point of view ; and should the reasonable expectations to which their discovery has given rise, not be disappointed, will influence in no small degree the prosperity of one of the most extensive and important regions of the state. From the Potomac to the south-western counties, the minor ranges of mountains, rising in general along the western boundary of the valley, are known to include beds of this mineral in the various conditions of a pure anthracite, and a compound containing variable but never large proportions of bituminous matter, and which may accordingly be denominated semi-bituminous coal. In Berkeley county, on Sleepy creek and elsewhere, openings have been made, from which an anthracite of the very purest character is obtained. In Frederick, Shenandoah, Rockingham, Augusta, Botetourt and Montgomery, similar discoveries have been made ; the coal of the four former counties, as far as yet examined, being nearly identical with that in Berkeley, while that found in Botetourt and Montgomery contains a considerable portion of bitumen, though far less than that of ordinary bituminous coal. The veins which have as yet been examined, vary from three to seven feet in thickness. That represented in the profile, dipping west into the Little North mountain, near Coal run, in Rockingham, is about four feet thick. Several openings at different points in the neighbourhood, present no perceptible variation in the character of the coal, which is a pure anthracite, capable, as experiment has shown, of burning with but little flame, and with the production of a very intense heat. At this place, and it would appear also in others in the same range, the coal readily falls into small fragments, exhibiting numerous rubbed and shining surfaces, leading to the impression, which an examination of the enclosing rocks would also indicate, that a dislocation of the strata has occurred, attended with a sliding and grinding action of the roof and floor of the veins, breaking up and fissuring the included coal, and occasioning by the mutual attrition of the contiguous surfaces that peculiar lustre and striated appearance which they invariably exhibit. In some of the veins, however, this crushing effect

appears to have been but little felt, and the coal comes from the vein in larger and more permanent masses. A further exploration of those veins, in which the coal has been thus reduced, may bring to light other portions of the vein, in which comparatively little of this grinding and crushing action has occurred. For some purposes, this broken condition of the coal would not impair its usefulness, but for general sale it would affect its market value.

According to an analysis of the Berkeley *coal*, executed by my brother, Professor H. D. Rogers, it contains in the one hundred grains only 4.94 grains of gray ash, all the remainder consisting of volatile and combustibile matter. This indicates a purity exceeding that of the Pennsylvania anthracite in general, which at a mean contains about six per cent. of ash.

In the *coal* from the Catawba, I have found varying proportions of bitumen in the specimens from different localities. An average of these results indicates about 14 per cent. of volatile matter, chiefly of a bituminous character. This coal burns with but little intumescence or swelling, is not much inclined to cake, has no tendency to splinter when burning, and forms a large amount (upwards of 80 per cent.) of a very superior kind of coke. Allusion has already been made to the probable value of this mineral, in connexion with the iron manufacture of this part of the state; but further explorations of these veins, together with careful chemical analyses of the coal as well as iron ore, and actual trials of the former as to its qualities in the furnace, are yet required, in order to determine with certainty the usefulness of this coal in the raw or uncoked condition, in reference to this branch of industry. In connexion with these remarks, and more especially as suggesting an important hint to those who may be endeavouring to bring these dry coals into use in the way alluded to, it may here be added, that from the great success attending the use of the *hot air blast* in France and England, where, in some cases, coals in the raw state, of an analogous character, are employed, the introduction of the same mode of operation here, holds out the promise of most profitable results; and it may be further suggested, that the great efficiency and economy of the *hot air*, even according to the trials made in this country with the ordinary materials used as fuel in our furnaces, ought at once to excite the attention and awaken the enterprise of all who are concerned in this highly important branch of our manufactures.

The sandstones, limestones, and slates of this region, are all of them convertible to useful purposes. The pinkish variety of the former is quarried in the North mountain to furnish hearths for furnaces, and has a hardness and sharp grit, which has led to its employment as a substitute for the more expensive millstones. The slate is largely impregnated with iron pyrites, and upon exposure to the air yields a great quantity of sulphate of iron or copperas, as well as sulphate of alumina or alum. It is for this reason, that the springs of this part of the state so frequently possess a sulphuretted, chalybeate, and acid character, and that some of them are so powerfully remedial in cutaneous and various other diseases. The celebrated alum rock on Jackson's river, consists of nothing but this slate, which here rises in an abrupt and lofty cliff, forming a semi-circle at the bend of the river, and presenting a scene which is at once curious and imposing. Over the surface of the wall-like precipice, streaks and stains arising from the copperas or ferruginous matter of the rock, may everywhere be seen, and large nodules of a spheroidal form, and of the size of a bomb, lie here and there embedded in the mass. Such is the amount of chalybeate and other saline, as well as sulphureous matter in these slates, that the inhabitants of the country, in lieu of resorting to the springs, of which some, as the Alum spring, are much in vogue, are accustomed to make use of the detached fragments of the rock, which in small quantity will impart to water all the flavour and effects of the springs themselves.

Chalybeate and sulphuretted springs break forth in various places from the pyritous slate above described, many of which, as for example, the Botetourt, Augusta, Rawley, Shannondale, Yellow, and Alum springs, have acquired reputation for their medicinal virtues. Thermal waters abounding in free carbonic acid and nitrogen gases, resembling those of the Warm spring valley, occur in some localities, an interesting example of which may be seen in the neighbourhood of Kaiser's, in the gorge of the Rich Patch mountain. Analyses now on foot in relation to the characters of several of those waters, forbid the publication at present of any decisive results, but it is hoped, that by an early day some account of their constitution will be embodied in a treatise on the mineral waters of Virginia, now in course of preparation.

Of the *limestone*, it may be merely stated, that it is capable of fur-

nishing a lime fully equal to that of the valley, and that the extent to which it exists in the deep valleys of this region, renders it accessible for agricultural purposes on almost every farm. Many beautiful and fertile spots possessing the advantages here stated, lie enclosed among these mountains, which, with facilities of transportation, must, at some not distant day, be looked upon as choice places of the state.

Iron ores similar to those of the valley, abound on the flanks of mountains where the limestone occurs, and many successful furnaces are supplied from this source. At Jordan's furnace, near the Mill mountain, castings of a very superior quality are made from a hematite procured in the neighbourhood of Brushy ridge; and at no great distance above, on the Jackson's river, the enormous water power which is here given by the torrent as it makes its way through the Rich Patch mountain, is in part applied to give action to the machinery of a large and successful forge. Facts of this kind, though new to very few, are calculated to fix our attention upon the great resources in materials and motive power which these wild districts of the mountains possess, and thence to illustrate the public advantages which are at some future day to flow from the establishment of proper facilities of communication with them, and the direction of wealth and enterprise to the practical development of the riches which they contain.

Most of the rocks of this region, contain numerous fossil impressions. The bare sandstones on the summit of the North mountain, seen from the road in passing from Lexington to Covington, display a great profusion of encrini and other zoophytes; and the sandstones of the Mill mountain, Rich Patch mountain, &c. present similar vestiges of organic life, together with hollow casts and marks of shells. In addition to such traces the surface of these rocks occasionally exposes those waving ridges which are known to geologists as *ripple marks*, and which are referred by them with almost undoubted certainty to the same causes as are found at the present day, producing precisely similar markings upon the sandy surface of the ocean beach. Large exposures of the rocky surface, thus beautifully rippled, may be seen in numerous parts of the North mountain, and the other remoter ranges, and under the above view of the origin of this curious feature of the rocks, are calculated in a

beautiful manner to illustrate the circumstances under which the strata of this region were deposited.

The slates, particularly those in the neighbourhood of the coal veins above referred to, present large and perfect impressions of fern leaves and other vegetable remains; and the limestones are rich in shells and madrepores of various kinds, and often of uncommon size. Fine specimens of *terebratula* and *caryophyllea* may often be obtained entire.

A curious and imposing feature in the rocky scenery of many places in this region, is the bent or arched arrangement of the strata.

In following the windings of the Jackson's river through the wild and picturesque valleys and gorges by which it makes its way into the more open region towards the east, this strange conformation of the rocks is seen in several places, furnishing in the stupendous elevation of the cliffs, and the massive character of the beds of which these arches are composed, the most instructive and magnificent illustrations of some of those agencies to which geologists are accustomed to refer. One of these instances of bent strata, particularly worthy of observation, is presented in the deep cleft of the Rich Patch mountain, through which the river makes its final escape from the rugged region in which its progress has been previously so much obstructed. Looking from Kaiser's, or the Forge, the naked side of this huge defile, towering in a nearly vertical wall, washed at its base by the impetuous torrent which flows eastward with a rapid descent, exhibits the grand spectacle of an enormous and almost unbroken arch of sandstone rocks, rising at its extremities in steeply dipping lines curving with more gentle inclination to its summit, and spanning a distance of several hundred yards. Thin ledges of a very hard variety of the same species of rock project at the abutments of the arch, and rise along the side of the cliffs in a nearly perpendicular direction. On the opposite side the same position of rocks is seen; but here, in many places, the continuity of the arch is broken. A similar scene, though on a smaller scale, is presented in the gorge by which the Calf Pasture river finds a passage through the North mountain; and indeed it would appear, that this feature in the position of the strata, is a common occurrence in all the mountainous ranges of this wild and beautiful region.

Proceeding westward in the profile, we come upon the heavy beds

of sandstone of the Warm spring mountain, dipping rather steeply to the east—on the western base of which, we meet with a fossiliferous limestone, having the same dip, and therefore lying beneath the sandstone. Bounding this valley on the west, the Little Warm spring mountain and its prolongations, exhibit the same rocks in the same relative position, with this important difference, that they all dip west. The relation of the rocks thus described, and as they are represented in the section, admits of a simple explanation, by conceiving a violent upthrow to have occurred along the line in which the valley now exists. The sandstones thus thrown off on both sides, left the deep fissure in which the limestones elevated by the same upheaving action, were revealed to observation. In this view, the mountains bounding the valley have been formed merely by the forcible protrusion on either side of beds of sandstone of enormous thickness, which were originally in a horizontal position—and the limestone which appears dipping in opposite directions and beneath the mountains, was brought into view by the same agency, although previous to its elevation it must have existed at a depth of nearly 2000 feet below the surface. This valley has, therefore, the character of an enormous fissure, and considering it in that light, we have no difficulty in accounting for the number of *thermal* springs which it contains. The well established fact that the temperature of the earth's strata increases with their depth from the surface, in connexion with the structure of the valley here described, will at once explain the elevated temperature which all these springs display, while peculiarities in the mineral ingredients of the subjacent beds, which it may readily be imagined would account for the gases which they evolve, as well as the saline and other ingredients which they hold dissolved.

In connexion with these views, it is important to remark, that the fossils and other characters of this limestone distinguish it from those which are found among the mountain chains to the east or west, and that it bears a striking analogy to the fossiliferous limestone formerly described as existing in the great valley of Virginia. Granting the identity of the two, we would thus have the slates and limestones of our valley occupying a position at great depths below the various mountains and valleys we have been describing, and only appearing at the surface where some great uplifting force has

operated, as in the Sweet spring valley, tossing away the upper and more recent strata.

Throughout all the region of which this portion of the profile may be considered as giving merely a local representation, the thermal waters, in virtue of the carbonic acid contained in them, hold in solution large quantities of carbonate of lime. The carbonic acid in quickly escaping from the water by exposure, permits the calcareous matter to separate, and thus, as the stream proceeds, this ingredient is precipitated at every step. Hence it is, that we find the channels of the streams thus impregnated, covered with a hard incrustation, accumulating in thickness every day, and even the stones and twigs over which the current flows, becomes encased in a film of semi-crystalline calcareous matter. Agitation of the water favouring the escape of the solvent carbonic acid, will also contribute to the rapidity of this accretion, and accordingly it is found, that where the ripples are numerous, the deposit is comparatively abundant, and what at first view seems most strange, even the ledges over which the streams are precipitated in cascades are themselves built up by additions of the calcareous deposit. The travertine formations of these valleys, produced in the way we have just described, are in some cases of immense thickness and extent. That in the neighbourhood of the Sweet springs, has in all probability, a thickness in some places of upwards of 100 feet, and every year adds slowly to its amount. At the Falling spring, nearly on the route from Covington to the Hot springs, a still greater depth of this deposit has been accumulated, and in various other places throughout this region, masses more or less considerable of the same curious formation, may be met with in the valleys, and sometimes even at considerable elevations on the sides of the hills.

The travertine, like that already alluded to as existing in Jefferson, Frederick and other counties in the valley, is capable of being made highly useful in agriculture, and of yielding a lime of the greatest purity and whiteness.

In the mountains west of the point last referred to in the profile, we discover the ternary series of sandstone, limestone and slate, as before described; the limestones showing themselves altogether on the flanks of mountains, and then only occasionally peeping forth. As represented in the profile, repeated alternations in the dip of the strata occur in this region, and the structure of the ridges is ge-

nerally such as to present a dip outwards on both their eastern and western sides. Progressing westwards, the overlying slate is increased in thickness by the addition of other, and not exactly similar beds, over which, and generally dipping to the west, we find the sandstones and slates on the western flank of the Alleghany mountain as presented in the neighbourhood of the White Sulphur springs. Among the numerous ranges of similar structure to that exhibited in the profile, and which are usually denoted by the common name of Alleghany, veins of coal have been discovered in many places, and the black shale usually accompanying this mineral is of frequent occurrence. One of these veins is exhibited on the profile, as seen in the vicinity of Crowe's, near the base of the Sweet spring mountain. A similar vein about three miles north of Lewisburg, furnishes a coal which, according to the trials which have been made of it both in smith's forges and in ordinary grates, has been shown to be of good quality. Most, if not all of these coals, are of the semi-bituminous character, and are, therefore, not much prone to cake while burning.

Bands of fossiliferous slate and sandstone are exposed to view in many places among the mountain ridges of this region. The hard dark brownish sandstone, generally seen lying in bands of a few inches thickness, is often largely stocked with fossil impressions. A single stroke of the hammer will frequently reveal, over an extensive even surface of the fractured rock, multitudes of such casts, chiefly the joints of *encrinurus* of various species; and so common is the fossiliferous rock throughout these mountains, that a large proportion of the broken masses met with in the channels of the streams and in the numerous dry ravines which form the beds of winter torrents, are rich in curious and instructive fossil traces.

The calcareous matter which once formed so large a portion of these various rocks in the shape of shells and zoophytes, has entirely disappeared, leaving hollow moulds, marking the form and character of the fossils which have been dissolved away. Yet so distinctly do these casts preserve all the delicate lines and marks of their originals or seals, that they furnish the scientific observer with a sufficiently definite knowledge of their peculiarities to enable him to refer them to their proper places in the arrangements of the naturalist, and by comparing them with the fossils of the other

strata and other regions, to make important inferences concerning the geological epoch of their existence.

In the limestones of this region fossil impressions are equally abundant. At Callahan's and near Crowe's, the mass of the rock appears chiefly to consist of solid casts of shells, which, with a little care, may frequently be detached entire, exhibiting unimpaired, all the peculiar features of the shells themselves. Perfect specimens of species of terebratula and productus may be procured at these and numerous other localities; and with a little research, a rich collection of fossils may be gathered in almost any part of this region, comprising a variety of species unknown in the geology of Europe. Seeing, from the character of these impressions, that the living beings whose traces are thus engraved upon the rocks, were once the inhabitants of an ocean, we reflect with wonder upon the curious geological changes which have occurred since the period in which the exuviae of these shell fish and zoophytes were gradually accumulated in the sand and mud at the bottom of the sea, and we look with new interest and astonishment upon the solid texture and towering height of the rocky strata in which these unequivocal traces of *oceanic life* are thus durably impressed.

One of the most valuable of the rocks occurring in this region, is the brownish slate, of which the firm and even surface of our mountain roads is now frequently formed. The existence of this admirable material immediately adjacent to the roads in many parts of this region has already exerted a most happy effect in their construction and improvement, and has rendered them for beauty and convenience, deservedly the boast of this portion of the state.

The numerous *mineral springs* for which this region is so celebrated, and which, perhaps, constitute its most valuable possession, could not be properly described in the narrow compass of the present report; and as injustice might be done by such meagre notices as it would be possible to introduce, a special description of their character and contents, and of the geological features of the surrounding country, will be reserved for another publication, now in progress, in which such details will be given in all the amplitude they deserve, and from which, should the *minute* geology of this and other parts of the state be called for by the legislature, all the im-

portant particulars bearing upon this point will be borrowed and incorporated in a more detailed report.

Among the general considerations in relation to them, which may with propriety be introduced in this place, it is worthy of remark, that while the thermal springs to which we have referred, in treating of the Warm spring valley and other places, appear to be indebted for their impregnation chiefly to rocks of a calcareous description, and are accordingly found in or near such rocks, the sulphuretted springs now referred to, among which are the White, Red, Salt, Blue and Gray Sulphur springs, appear to derive most of their ingredients from pyritous slates, and will therefore be observed to rise through or in the neighbourhood of strata of this nature. Of these, the White Sulphur is the only one which can be regarded as decidedly thermal, its temperature being about 64° , while the others do not vary considerably from the usual temperature of the ordinary springs around them.

Another point of a general character which may be noticed here, is the radical difference as to saline and gaseous ingredients observable between the springs formerly alluded to, and those of which we now speak. All the waters of the Warm and Hot and Sweet springs valley, and several others of analogous character, and highly thermal temperature, discharge considerable quantities of free gas, consisting of carbonic acid and nitrogen, of which the latter was first distinctly recognised by myself, and found in general to be present in very great proportion.

At the same time a large amount of carbonic acid is held in combination in these waters, imparting the acidulous character for which some of them are remarked, and giving them the power as already mentioned of holding large quantities of carbonate of lime dissolved. This acid impregnation is in no instance more strikingly manifested than in the waters of the Sweet spring valley, of which, that of the Red spring about a mile below the principal fountain of the Sweet springs, presents an amount of the combined gas equal in volume to about one half of that of the water itself.

Another important distinctive feature in the constitution of the class of springs here spoken of, is the large amount of the *carbonates*, principally that of lime, and the comparatively small proportion of the *sulphates* with which they are impregnated.

On the other hand, the class of *sulphuretted waters* as exemplified

in the springs previously named, contain but little carbonic acid, and a comparatively minute amount of carbonate of lime, or other carbonates, while they are richly fraught with sulphuretted hydrogen gas and various sulphates, of which those of lime and magnesia are present in most considerable proportion. Besides the several points of distinction above referred to, it may be further added that the sulphuretted waters are in general impregnated with various organic matters of very peculiar characters, which by collecting in the reservoirs and channels of the springs, in mixture with precipitated sulphur, have, by the various beautiful colours which they impart, given rise to the different appellations by which the more celebrated of these fountains are now known. But while such general resemblances as have been described, will be found to prevail among the several springs of each class as thus characterised, it is at the same time to be remarked that they possess striking individual peculiarities, imparting to each an amount and species of medicinal agency in some degree appropriate to itself.

Viewed singly in relation to the number, variety and high reputation of its mineral waters, this region is well entitled to be proud of the vast resources of which it is possessed. Grouped as these springs are at moderate distances apart, presenting within the same district a variety of medicinal character, for which in other countries, regions remote from each other require to be visited in succession, placed at a point equally accessible to the inhabitants of the seaboard and the great valley of the west, and situated in a region of grateful summer temperature of salubrious climate and of picturesque and of diversified natural beauties, they are now rapidly attaining a celebrity for powerful and varied remedial qualities, as well as for the refined social enjoyments which are annually gathered around them, destined ere long to eclipse the older reputation of the famed fountains of the northern states, and to vie even with the long established character of the most noted of the watering places of the old world.

Among the valuable minerals of this portion of the state, mention should be made of the rich *iron ores* occurring along the ridges in numerous places, and which, from the frequency of coal seams among these mountains will one day be brought into profitable use.

Saltpetre is found mingled with the earth in many of the caves in this region, and has been procured from time to time in con-

siderable quantities from this source. This earth or petre-dirt, as it is called, is obviously a sediment deposited from the waters, formerly or at the present time found within the caves, and has sometimes a texture of such impalpable fineness as to indicate that the deposition took place while the liquid was in a very quiet state. Besides the saltpetre or nitrate of potash, it also contains a large amount of nitrate of lime, which, by the usual process of mingling the washings of common ashes with those of the petre-dirt, is by a direct chemical action converted into saltpetre. Immense heaps of the earth from which the salt was formerly obtained, may be seen in some of the wide chambers of the Singing and other caves, which there is reason to believe in process of time, will become as rich in this substance as before.

In the same caves *Gypsum* is also found mingled with the petre-dirt, and sometimes enclosing large lumps of it in a thick crystalline envelope. In the Organ Cave so much of it is found both in this condition and replacing the shells originally existing in the slaty limestone, as to make it worthy of inquiry, whether it might be turned to profitable use.

Returning to the profile at the point marking the intersection of Howard's creek with the line of observation, we remark the commencement of a series of sandstones and slates differing from those of the Alleghany, and presenting that want of accordance in the dip which may probably mark the beginning of the great western series. The rocks of the former kind here exhibit what is called a *diagonal lamination*, a structure very general among the sandstones of the west, and one from which the geologist derives important hints as to the natural circumstances existing when these strata were deposited.

On the eastern side of the Greenbrier, is an outlying hill composed of horizontal beds of limestone, resting upon red and green friable slate. At several points south of this, in a direction towards the Salt Sulphur springs and Uniontown, this limestone is discovered, and in proceeding some distance towards these points, the hills as well as valleys present scarcely any other rock but a limestone, which, judging by its fossils and other characters, may be regarded as probably the same as that here represented. Beyond this point, we meet with west-dipping strata of reddish shale, with a thin band of limestone on the descent of the hill, approaching Lewisburg.

This brings us into the fine limestone valley, on the confines at which that town is situated, and here we find the rock dipping at first very gently to the west, then becoming horizontal with slight undulations, covered beyond Tuckwiler's with a soft arenaceous rock, approaching to sandstone in appearance, but which is in reality merely the earthy insoluble portion of an impure limestone, from which the calcareous matter has been all dissolved away. Beyond this point, the limestone rises with an eastern dip, in the neighbourhood of Milligan's creek, after which, at the eastern base of Muddy Creek mountain, it is seen dipping westward beneath and mingled with the strata of soft slate, and again appears on the western side of this ridge near its base, coming out with a dip in the opposite direction. Finally, it shows itself capping the remoter part of Brushy ridge, and dipping in a westerly direction, as if prolonged beneath the heavy beds of slate and sandstone of which the Meadow mountain is composed. After this, it is not observed to re-appear in proceeding further west.

Whether as has been supposed, the limestone which has just been traced, is continuous with the extensive beds of this description which are spread over a wide district to the south, forming but a part of one general deposit of which the horizontal limestones in the vicinity of the Salt Sulphur springs and Uniontown, and even of the red Sulphur, are merely other portions, it would as yet be premature to venture upon deciding. No such identity of fossil and other characters has so far been observed in the rock from these different districts to authorise a generalization of the kind, and it must be left to minute future investigation to ascertain the true relations subsisting between these beds.

The extent of the limestone region south and west of Union, is as yet but imperfectly ascertained. Passing the Gray Sulphur springs, and proceeding to the south-east side of the Peter's mountain, we find around the base of the Angel's Rest and Salt Pond mountains, and throughout the valley in which Parisburg is situated, a wide extending stratum of nearly horizontal limestone, much of which along the New river, is remarkable for containing masses of silicious rock, embedded in its substance, sometimes having the horny aspect and hardness of genuine flints. Most of these fragments, however, are irregular in form, and bear a striking resemblance to the white and very compact sandstone which is seen profusely strewing the flanks of the Peter's mountain for many miles

around. In several specimens, I thought I could perceive indistinct traces of encrini, such as are frequent in that rock. Possibly, however, these masses may have become entangled in cavities on the limestone, in which by chemical action, they were subsequently cemented.

One of the most curious objects in the particular district of which we have just been treating, is the lake near the summit of the Salt Pond mountain. The erroneous impressions and absurd speculations to which it has given rise, will be accepted as an apology for the few descriptive remarks which I shall here present. This beautiful sheet of water is situated at the intersection of the Salt Pond mountain and several of its spurs, and not, as is commonly supposed, on the top of the mountain. Its height above the base of the mountain, is probably from 900 to 1000 feet, but it is surrounded by steep and lofty hills on every side, excepting that by which it is approached, and that through which its waters find a small outlet, falling in a picturesque cascade of great height, and then flowing rapidly into the creek below. The outlet appears formerly to have been deeper than at present, and the extent of the lake was therefore much less than it now is. Rocks and earth gradually accumulating at the passage, have dammed the waters up, and hence the trees and shrubs which grew upon its margin, may now be seen sometimes standing erect at a considerable depth beneath its surface. Its length is about three quarters of a mile—its greatest width about half a mile. By careful soundings from side to side, in many parts of it, the greatest depth that could be found was from 56 to 60 feet; but such was the transparency of the water, that the bottom could be seen nearly in its deepest parts. No animal is found in it but a small species of salamander or water lizard.

Of the *south-west* portion of the state so little is known, further than the existence and value of its gypsum, lead, salt and iron, that no general views, even of its important geological features, can be ventured on with safety for the present. Even the tracing of the limits of those formations that connect a portion of it geologically with the great Virginia valley, would as yet be premature; and of the true character of the more western parts, we have no means at present of forming any accurate opinion. Hence, in introducing the few remarks relating to its structure and economical resources, which I shall presently bring forward, little or no regard will be paid to any imaginary lines of demarkation, which might be conceived

separating from each other the distinct geological formations which there is but little doubt that it includes.

Through an exclusive attention to the direction of the drainage of the northern and eastern portions of this division of the state,—as, for example, in Montgomery county,—the designation of Alleghany has been very strangely and unphilosophically applied to a comparatively elevated portion of the table lands of that county—and guided by the same principle, in tracing a supposed connected chain which forms the water-shed of both the east and west-discharging rivers, the same title has been applied to a portion of the Blue Ridge, constituting the western boundary of Patrick and Grayson counties. Thus we have the same term applied successively to ridges entirely dissimilar in regard to the materials of which they are composed, and the epochs to which they are geologically to be referred; and what is of much more practical importance, mistaken conceptions of the nature and resources of these districts will be almost certainly suggested, on a first view of them, as delineated upon the map, from the prevailing idea, that a continuous mountain chain, thus bearing a common designation along its entire extent, must of course exhibit great similarity in structure and materials throughout all its parts. Nor is this all: by following the fallacious guide of the direction of the drainage, instead of actually tracing continuous ridges, likely to present a general similarity in character throughout, we are in many cases giving an imaginary continuity to elevated portions of land frequently belonging to successive ridges, and thus creating in imagination a connected mountain in a direction or directions in which none such actually exists. Hence, nothing is more common in descriptions than to hear of the Alleghany *passing under* the Peter's mountain, near the Sweet springs, traversing the various ridges to the east until it arrives at Christiansburg, and thence by many crooked courses, tending towards the Blue Ridge, until reaching that mountain, it suddenly cuts it off, and bends its own course to the south-west. But during all this description, the speaker is seldom aware that he is describing what, to a great extent, has no original in nature, and that what he represents as one mountain, a continuation of the great Alleghany of the upper and middle portions of the state, here striking across the numerous ridges to the east, and making in its way in that direction under and over and through the numerous mountains which seem crowded in

a phalanx to resist its course, is, in reality, through much of its extent, only a series of spurs, sometimes merely elevated table lands, dissimilar in structure and origin amongst each other, and only associated in an imaginary connexion by the accidental circumstance that they form one portion of the water-shed of the east and west-discharging rivers. A more accurate knowledge of the topography of the state, and more judicious principles in the application of terms, will, it is hoped, at some future day, correct this preposterous error in the designation of our mountains, and will substitute on our map such names as the real constitution of ridges of analogous formation throughout, would render natural and appropriate. Thus the western boundary of Patrick and Grayson ought to be called Blue Ridge, and no ridge or mountain east of the Peter's mountain can, with the least propriety, be entitled Alleghany.

OF THE SOUTH-WESTERN DISTRICT OF THE STATE.

In exhibiting a few particulars relating to mineral structure and resources of the south-west, we will confine our attention chiefly to the limestone, lead, gypsum, salt and coal, which it possesses.

Much of this region is overspread with fossiliferous limestone of various kinds, as well as other varieties containing no fossils, and approaching in some places to the character of marble. Semi-bituminous coal is found in several localities, as on Strouble's run, &c. in Montgomery, and in other places in the Brushy and Walker's mountain. Iron ore is also abundant in the same districts.

The *lead ores* of Wythe, under judicious management in the working, and with favourable means of conveying the resulting metal to the proper market, could not fail to become a large source of profit to the state. In the forms of sulphuret and carbonate, they contain a large per centage of the metal, and require no expensive arrangements for the reduction, the sulphur in the one, and the carbonic acid in the other, readily escaping under the application of a heat of moderate intensity. Both of these ores are wrought, although of late it would appear that the carbonate is preferred, on account, it is said, of its yielding a lead of purer quality. The sulphuret, as is frequently the case, contains probably antimony or arsenic, perhaps both, while the carbonate is much more likely to include no other metallic ingredient but the lead. Until lately, the

ore of this description, from its earthy appearance in most cases and its total want of an external metallic aspect, had been rejected as of no value, and it was only by accident that its character was revealed to those who were working in the mines.

The sulphuret or blue ore (galena,) occurs in veins of rotten or chalky limestone; the carbonate, in beds generally situated at the intersection of the veins. In the extraction of the metal the fuel employed is wood, and the operation is performed in a simple reverberatory furnace.

The *gypsum*, as far as certainly known, occurs over a space about 20 miles in length, and half a mile in breadth, but probably the area actually occupied by it is much more considerable. The depth to which it extends in some places is enormously great. It lies in beds between strata of limestone, slate, and sometimes sandstone, and has to be penetrated for a great depth in boring for salt water. In some cases it is said to have a thickness of nearly 300 feet, including the bands of rock among which it is stratified. Its condition is either that of a fibrous crystalline mass of nearly perfect purity, or a granular bluish-gray and veined rock, containing a small amount of earth, but still as little mingled with extraneous matter as any of the imported plaister. This precious material, owing to the difficulty of transportation, is yet unknown at any distance towards the seaboard, but during favourable seasons it is conveyed in arks down the Holston, to the south-western states, and in this way yields a handsome profit. With facilities of transportation, what incalculable benefits might the great valley of Virginia, and much of the region west, as well as east of it, derive from this invaluable deposit, and what an active and productive commerce might it give rise to throughout that region in which it is found.

The *salines* constitute another of the treasures of this district of the state. As yet but little has been done, either towards determining the extent of the saliferous strata, or the chemical nature of the various ingredients, besides the common salt, which the brine holds dissolved. At the salt-works on the Holston, the wells are usually from two to three hundred feet in depth, presenting strata of limestone near the surface, sandstone or slate alternating with beds of gypsum several feet in thickness, next beneath, and finally, a stratum of clay, within which the salt-water is procured. This clay is of a reddish aspect, and a very argillaceous texture, being in all

probability a softened shale, such as that of the brine springs and rock salt of Cheshire in England. In fact, a marked analogy is presented in the structure of the salt region of the Holston, and that of Cheshire. In the latter, beds of *gypsum* are found alternating with strata of indurated clays and sands, approaching to slates and sandstones; and carbonate of lime exists largely in the strata lying near the surface. In all these particulars the salt region of the Holston corresponds with it very closely.

The great value of the Cheshire region, however, results from the heavy beds of rock salt which it includes, and of the existence of such upon the Holston, though far from improbable, no positive testimony has as yet been obtained.

The curious fact, that on some occasions granules or small crystals of salt, are brought up by the water of the wells, is certainly very much in favour of the opinion, that such beds of the massive salt do actually exist at depths to which the borings hitherto made have not extended, and furnishes strong additional incentives to a persevering and thorough exploration by borings in numerous places penetrating to still greater depths.

The proportion of common salt varies with different wells, and even in the same is not perfectly uniform. In some cases 10 gallons of the brine will yield one gallon of salt, in others 16 are necessary. Taking the specific gravity of salt at about 2.5, and allowing something for the interstices in the dry measure, we would have in the former case a strength of about 20 per cent. Gypsum is always present in the brine, and is almost the only impurity in it.

Of the *coal* occurring in Montgomery, and other parts of the S. W. region, nothing at present need be added, as the remarks already made in regard to the beds of the same variety of this mineral, occurring in the Catawba mountain and elsewhere, would be equally applicable to those found further south. Iron ore of a very peculiar character is found in Grayson and Wythe, &c., yielding in some cases by the usual smelting process, a metal having all the qualities of steel.

The composition of this ore, now not known, would throw great light on this interesting result, and might enable those engaged in the iron works of the country, to secure a uniform production of this more valuable form of metal, instead of being subject to the

capricious results of having cast iron at one time, and at another, without any apparent reason, a superior quality of steel.

THE GREAT WESTERN BITUMINOUS COAL AND SALT REGION.

We come now to treat of that enormous area of nearly horizontal strata which we have designated as the fifth great geological subdivision of Virginia. It comprises as already shown, the large territory lying between the western limits of the state and an irregular line of mountain ranges as yet imperfectly determined, but nearly coinciding with the eastern front ridge of the Alleghany, the Greenbrier mountains and the great Flat Top mountain. No section of the whole state offers perhaps so much that is characteristic, either in its physical geography or geological structure, and none holds out richer promise of valuable practical results as soon as it shall be systematically explored. By far the greatest portion, if not all, of its strata, belong to a group of formations, distinguished not only in America but through the world, as being the chief depositories of *bituminous coal*. The title of the western carboniferous region might therefore seem to be appropriately applicable to it, were we sure that it might not convey to geologists and others a possibly erroneous conception of the class of rocks which it comprehends. While it is clearly referable to the general period of the bituminous coal, it is by no means meant to signify that the rocks of the region correspond with any exactitude, or indeed have any mineralogical analogy to the strata which comprise the bituminous coal formation of most geological writers. Nor, on the other hand, is it settled, that the era of their production was precisely the same during which the coal beds of other countries were deposited. We hold it to be altogether premature, while the geologists of America are yet only on the threshold of their researches, to endeavour to establish an identity of *names* between our strata and those of Europe. This too frequent error, prejudices all the broader and more lofty generalizations of the science. In a spirit of caution, therefore, dictated by the many blunders daily committed in the nomenclature of our rocks, we shall abstain from giving them a class of European names, not always indeed applicable in the countries where they are employed, and certainly less so in a region of widely different structure, separated by the great interval of the Atlantic. The little that

can be said in a detailed way upon particular strata will be descriptive, being convinced that points of nomenclature and classification cannot be ventured upon with profit until there shall have been collected a vast deal more minute information than is now before us.

This western section of Virginia is characterized throughout by geographical features of great simplicity. The surface of the region is undulating, and towards its south-eastern limit, mountainous; but the loftiest hills rise in gently swelling outlines, and no very prominent peaks tower in acute and ragged lines, to denote that the strata have been subjected to violent convulsive and upheaving forces. Every thing bespeaks it to have been at one time an expanded plain, gently tilted from the horizontal position, so that its surface and the beds of rock beneath, decline with a slight but very uniform depression, very generally towards the north-west to the valley of the Ohio.

The form, direction and character of both hills and valleys, give evidence that its inequalities of surface were caused by the furrowing action of a mighty and devastating rush of waters, which by a rapid drainage scooped out enormous valleys and basins in the upper strata, the remnants of which are consequently traceable across the widest valleys from hill to hill, holding the same elevation, thickness and inclination to the horizon. It is from this deep excavation of the strata by natural causes, combined with the other important circumstances of a nearly horizontal position, that we are to draw our estimate of the prodigious resources of a mineral kind possessed by the region before us. Whatever valuable materials lie included in the strata of the district, coal, salt, limestone or iron ore, the horizontal position alluded to keeps them near the surface, or at an accessible depth, over enormously wide spaces of country, while the trough-like structure of the valleys, and their great depth, exposes the edges of many of these deposits to the day, under positions in which mining is the easiest imaginable, and with an extent of development not less accommodating to the researches of the scientific geologist than bountiful to the wants of the community. The same features prevail in the tertiary or tide water district of the state, and ought to awaken there a corresponding feeling of congratulation. The only essential difference of structure, is the far greater depths to which the beds of this western territory have been excavated or denuded. A greater number of strata are there laid

open, contributing to render the deep-seated beds of coal as accessible as the superficial marls of the lower section of the state, and thereby to preserve a beautiful balance in the resources of the two respective regions.

The portion of the profile representing this vast and affluent division of the state, along the particular line to which our observations were chiefly directed, may be regarded as commencing with the Meadow mountain, and extending as far as the Ohio; but by starting from the point here indicated, it is by no means intended to imply that the great western series of secondary rocks here actually commence. So far as an inspection of the ground along the route observed may be regarded as furnishing information upon this interesting point, the probable beginning of this series is to be looked for farther to the east, and in all likelihood, is placed on the western bank of Howard's creek, the only position in which an approach to unconformable stratification was observed. As however we have already described the limestones of the Lewisburg valley and the other strata with which they are immediately associated, and as moreover our chief object at present is the presenting some particulars relating to that portion of the great western series which is first distinctly observed towards the summit of the Meadow mountain, we shall waive all merely scientific inquiries with respect to the precise boundary of the western rocks, and proceed briefly to describe the structure of this region westward from the point already indicated.

Ascending the Meadow mountain, we meet with blue and red slate in a friable condition, until we arrive at a point more than half way to the top, where gray sandstones make their appearance, forming the cap of the mountain, and like the slates beneath, dipping with a gentle inclination to the west; descending on the western side the slates again appear, and continue throughout the whole of the extensive flat reaching to the base of the Little Sewell, on the eastern side of which they are soon lost, and a gray sandstone, like that already remarked, again comes into view. The upper portion of the Little Sewell consists of a gray and white sandstone, identical with that observed in progressing further west. Here one or more seams of coal have been discovered. On the western flank of this mountain, the red slate is again observed dipping gently west beneath the other rocks, and here finally disappearing under the beds.

of sandstone accumulating in thickness in our progress west. Continuing in the same direction, a series of these sandstones of various hues and different textures, including numerous seams of coal, and all dipping as before, but with a diminishing inclination, so as in fact to approach nearly to the horizontal, accompany us through the Big Sewell, Davy's mountain, Bracken's Ridge, Dogwood Ridge, Gauley mountain, &c., to a point west of Campbell's creek, where a gentle counter dip of the same rocks may be remarked, soon, however, exchanged for the general direction before observed. Here, as indicated in the profile, three great seams of coal display themselves almost continuously for a distance of about 12 miles, stretching in parallel and nearly horizontal bands along the almost mountainous cliffs forming the boundaries of the rich and lovely valley of the Kanawha in the vicinity of Charleston.

Beyond this point, the level of the country declining, we come upon a series of nearly horizontal arenaceous and argillaceous rocks occasionally presenting thin beds of limestone of various degrees of purity, in some cases containing sufficient alumina to render it valuable for hydraulic lime. This portion of the series extends as far as the banks of the Ohio.

The sandstones of which it will be seen so large a portion of this region is composed, are remarkable for the enormous size of some of the fossils which they contain, and the shales associated with the coal are even still more rich in some places in these colossal relics of a former world. A striking feature already alluded to in speaking of the sandstones near the valley of Lewisburg, is observed very generally throughout this region, and is exemplified in some of the cliffs of the New river and Kanawha, on a scale of vast extent. I mean the *diagonal lamination* of the rock—or, in other words, a subordinate stratification oblique to the general lines of demarkation of the several parallel beds of which the whole mass of the cliff or mountain is composed. A similar fact was noticed in describing the tertiary rock of broken shells at York, and the beds of gravel observed in the neighbourhood of Richmond and at other places in lower Virginia. In all these cases, a like agency has been at work in producing this curious structure. In all of them we readily discover the action of tides or currents, depositing upon a surface, originally, by some accidental cause, inclining to the horizon, the sands and pebbles, and other materials of the rock, and thus adding

layer after layer of the deposited material in directions parallel to the receiving surface, and therefore oblique to the general horizontal level. Changing intensity or direction in the transporting tide or current, would be accompanied by an alteration in the position or direction of the lamina thus formed—and it is easy to perceive, that an almost endless variety of structure in this respect might thus be readily explained. The fact here noticed, furnishes of itself a striking evidence, were any such wanting, of the submarine origin of the vast region of which we are now treating. But the organic remains which these rocks entomb, at once demonstrate this to have been the fact—the relics of marine animals being the only remains found among the sandstones which are not immediately associated with the coal.

With the view of illustrating the extent of mineral wealth of which this region is possessed, and at the same time of indicating the vast benefits which it may anticipate from a geological and chemical investigation of these resources, I will briefly refer to some of the more important deposits as yet known, of its coal and iron ore and salt.

At Wheeling, and for 14 miles down the river, the cliff or bank presents an uninterrupted bed of highly bituminous coal, upwards of 16 feet thick, and of such a quality, as to furnish fuel for all the dwellings and manufactories of that enterprising and prosperous town. Above and separated by other beds, are two thinner layers of this material, but of an inferior value. Associated with these seams of coal, and lying above the two lower ones, is a bed of limestone of upwards of twenty feet in thickness.

At Clarksburg and northward down the valley of the Monongahela, there exists one of the richest coal deposits in the state. One of the seams in some places in the neighbourhood of this town, is from 10 to 12 feet in thickness, below which, and separated chiefly by a heavy bed of sandstone, there lies a thinner stratum of a more highly bituminous character. These also are associated with a layer of limestone. We may form some idea of the vast extent of these coal seams from the fact, that from some distance above Clarksburg, they may be followed with scarcely any interruptions throughout the whole length of the valley of the Monongahela down to Pittsburg. Ascending the Tygart's valley river, the coal diminishes in thickness and valuable qualities, while the sand-

stones and limestones increase, the latter in the Cheat and other mountains, near the sources of the river, having a thickness of from 60 to 100 feet.

Coal is also found, though in less considerable seams, along the valley of the Little Kanawha. Near Hughes' river, one of its tributaries, it is very abundant; and in the same neighbourhood, springs of petroleum, or rock oil, have been discovered. North and west of this stream on the ridge, selenite or crystallized gypsum is said to occur, though at what place and to what extent, we are not informed.

On the Great Kanawha, the exposure of coal is one of the most extensive and valuable anywhere in the United States, and here from its immediate vicinity to the Salines, its practical usefulness has been tested on a wide and profitable scale. On the Coal, Gauley, and other rivers in this portion of the west, the beds of this mineral are frequently brought to view, and in fact no better general description can be presented of its extent, than that it is almost continuous with the vast beds of sandstone, which spread in nearly horizontal planes over nearly the whole of this broad region.

A coal containing much less bituminous matter, occurs immediately west of the eastern front ridge of the Alleghany, in Hampshire county, lying in nearly horizontal beds, in five successive tiers, and extending for a distance of many miles along the borders of the Potomac. A simple enumeration of the strata here exposed, will furnish an illustration of the resources of this corner of the state, well calculated to inspire astonishment and exultation. Upon a stratum of valuable iron ore, not less than fifteen feet in thickness, there rests a bed of sandstone, upon which reposes a coal seam, three feet thick; above this, another bed of sandstone, then a two feet vein of coal, next sandstone, then another coal seam of four feet; again a stratum of sandstone, and over it a seven feet vein of coal; over this, a heavy bed of iron ore, and crowning the series, an enormous coal seam of from fifteen to twenty feet in thickness.

The Saline formation, associated with the vast strata of sandstone before described, has as yet been almost unexplored, excepting in the valleys of the Great and Little Kanawha. High up, on the New River, and at one or two points on the Greenbrier, salt water has been found, and the erection of salt works has been attempted,

though hitherto these efforts have proved unsuccessful, either on account of the weakness or the insufficient supply of the brine. What may be the result of future research in the region east of that in which the salt manufacture is now successfully pursued, it would be impossible to predict, but from the fact, that the rocks of all this region, and among them the white sandstone from which the brine of Kanawha is procured, have a gentle western dip, it would appear reasonable to infer, that in the range of the Sewell mountains, and some distance east, where these rocks, which at the Salines are many hundred feet deep are brought nearly to the surface, the supply of salt water might in some places be obtained at a comparatively inconsiderable depth, and at all events, considering the continuity and identity of the strata over the whole of this wide area, we may reasonably suppose, that the saliferous bed or beds would be found in nearly every portion of it, though perhaps in many places having too slight an impregnation to render the water yielded, of any value in the manufacture of salt.

On the Great Kanawha, wells of various depths, rarely exceeding 400 feet, have been sunk on both sides of the river above Charleston, throughout a distance of more than twelve miles. The brine thus procured, unlike most other salt waters, contains scarcely any sulphate of lime or gypsum, on which account the process of obtaining the salt in a pure crystalline condition, is attended with fewer difficulties than usual; and for this reason, the alum salt now procured by the improved methods of operating recently introduced, may be regarded as muriate of soda, in almost absolute chemical purity. The importance and value of the Salines in this vicinity, may be inferred from the fact, that about three millions of bushels of salt are now annually made from them, and that in the manufacture of this article alone, more than twice the quantity of coal is consumed every year than is furnished by all the coal mines of eastern Virginia put together. This coal being procured from the hills adjacent to the salt furnaces, is obtained at comparatively little cost: presenting an example of the fortunate adaptation of the resources of a region to each other, of which few equally remarkable are to be met with anywhere in the world. Enterprise incited by so happy a combination of advantages could not fail of bestowing prosperity upon a region which is thus blessed, and we, therefore, find throughout the whole extent of the valley, where

the salt manufacture is pursued, and even over a wide extent of country, connected indirectly with its operations, a degree of activity and industry and wealth, which we would in vain look for in our rural districts generally, and which, when first beheld after quitting the wild and almost uninhabited regions by which the traveler from the east approaches the Kanawha, cannot fail to kindle in his mind a vivid sentiment of pride, astonishment and pleasure.

A general structure in all respects analogous to that presented in the portion of the profile last described, pervades the whole of that vast area of which the boundaries have been approximately stated in the beginning of this division of the report. But with features of strong general resemblance, it must not be imagined that local peculiarities do not exist in the different portions of this region, developing not only many objects of geological and curious interest, but also bringing to light many of the mineral treasures of which this favoured territory is possessed. There is no point of view, however, in which the immeasurable riches of this region are rendered more obvious to our minds, than that of the uniform and continuous structure which has already been described. For, it is in these widely spreading strata of sandstone, that nearly all the boundless treasures of this country are enclosed, and the continuous character exhibited by them, gives the strongest possible assurance of a like uninterrupted extension of the various beds of valuable materials which they include. In this view, how magnificent is the picture of the resources of this region, and how exhilarating the contemplation of all the happy influences upon the enterprise, wealth, and intellectual improvement of its inhabitants, which are rapidly to follow the successive developement of its inexhaustible mineral possessions. In a country where the channels of nearly all the principal rivers have been scooped out in part through beds of coal, where some of them are paved with the richest ores of iron, and where the very rock itself, the sterile sandstone of the cliffs and mountains, is enriched at certain depths with abundant stores of salt, what more is needed to fulfil the happy and glorious destinies that await it, than to awaken enterprise to a due appreciation of the golden promises it holds out, and to direct industrious and active research to the thorough investigation of the character, position, and uses of the treasures it contains?

Note on the fertilizing efficacy of Greensand, extracted from the report on the Geology of New Jersey, by Professor H. D. ROGERS;

“Mr. Woolley, of Poplar swamp, Monmouth county, N. J., manured a piece of land in the proportion of 200 loads of good stable manure to the acre, applying upon an adjacent tract of the same soil, his marl, in the ratio of about 20 loads per acre. The crops, which were timothy and clover, were much the heaviest upon the section which had received the marl, and there was this additional fact greatly in favour of the fossil manure, over the putrescent one, that the soil enriched by it was entirely clear of weeds, while the stable manure had rendered its own crop extremely foul.

“There can be no doubt that 20 loads of marl per acre must be regarded as an unnecessarily bountiful dressing, but computing the relative cost of the two manures when employed in the ratio above stated, we find a considerable disparity of expense in favour of the greensand. Placing the home value of farm-yard manure at 100 cents for each two horse load, and that of the marl at 25 cents per load, we have the expense of manuring one acre 20 dollars, of marling the same 5 dollars.

“Experience has already shown that land once amply marled, retains its fertility with little diminution for at least 10 or 12 years, if care be taken not to crop it too severely; while with all practicable precautions, the stable manure must be renewed at least three times within that interval, to maintain in the soil a corresponding vigour.”

PROPOSED PLAN OF THE GEOLOGICAL SURVEY.

The survey should aim at three principal results, each of which is essential to a proper developement of the native mineral resources of the state :

First, the production of a report descriptive of the minute geology, practical and scientific, of all parts of the state.

Second, the construction of a geological map and a series of accompanying sections or profiles, both necessary to a proper exhibition of the geology of the region, and capable of conveying a fund of useful information, which no mere report can.

Third, the formation of a cabinet designed to exhibit the mineral materials described in the report, and represented on the map and sections.

As a mere description of the geology of a country, if unaccompanied by a map and sections, can convey only a very imperfect idea of the structure and relations of its formations, it becomes necessary to have the geographical map as accurate as possible, inasmuch as errors in this will vitiate more or less the geology. The proper basis on which to lay down a geological survey, is a minute topographical map, the production, however, of which at the present time, would be too tardy and too costly. The existing state map being very inaccurate in various points, which, if retained in the geological map, might lead to serious practical mistakes, one duty of this survey should be to rectify such portions of the topography as must be corrected previous to laying down the geology. This implies a certain amount of topographical duty, which it is designed to perform only when rendered necessary by the demands of the geological survey.

To the topographical branch of the survey might be attached two or three extra duties, some of which would greatly promote the strictly geological part of the survey, and in like manner augment largely our stock of useful information upon the internal resources of the state. One should be to procure numerous *barometrical observations* of the heights of our mountains, more especially the gorges and passes over which roads may from time to time be carried. Another ought to embrace a set of observations on the drainage or *water power* of the several hydrographic sections of the state. This

would act usefully in all suggestions for canals, and also tend to the developement of manufacturing enterprise.

A general plan only can be given, according to which, it would be most eligible to enter upon the geological researches, for the movements of those engaged in the survey must be shaped to a considerable extent by the geological relations of the several districts of the state as they are brought to light. It is deemed proper that the first seasons be taken up *in part* in a general exploration of all the principal regions of the state, and in part in a detailed investigation in a systematic order of each class of formations. In this way a multitude of valuable facts easily reached, will be brought to light by the earliest possible day, and the regular execution of the state map will be in progress from the commencement of the survey, and its ultimate completion greatly expedited.

It is proposed to connect with these general examinations, a mass of chemical investigations, intended to be of immediate application in the employment of the materials brought under review; also, to render annual reports upon such points of the survey as are more pressingly wanted, and which are capable of being completed in a single season, reserving the minute and comprehensive description of the whole geology of the state for a general final report. These annual and specific reports can be accompanied by sections across the strata, the execution of which is compatible with much less time than is essential to the construction of the geological map. In this way much definite knowledge can be disseminated without waiting for the final completion of the enterprise, and the map will be greatly benefited by the investigations auxiliary to these profiles.

The facts, and general views of the geological structure of the state, brought to light in the reconnoissance, enable one to suggest nearly the directions most proper for the principal sections or profiles across the formations of the state.

It is proposed to make one lie between the Potomac somewhere near Alexandria and the Alleghany mountain near Cumberland; another from the Atlantic across the Eastern shore and the Chesapeake bay, at a point between the Potomac and Rappahannock rivers, to reach to the Ohio river near Fishing creek; a third to stretch from the Chesapeake bay between the York and James rivers to the Ohio near the mouth of the Little Kanawha; a fourth to commence at the North Carolina line between the Chowan and Roanoke rivers, and

to follow the general line of the Great Kanawha to the Ohio; a fifth to stretch from the North Carolina line, at some eligible point in Patrick county, and to meet the former section at the mouth of the New river; a sixth to reach from the same state line, some where in Grayson county, to the valley of the Guyandotte river, and to pursue the general direction of this to the Ohio.

The detailed location of these six great lines will be made to depend, in great measure, on local features, and the exigencies arising out of the peculiar geology and geography of each belt of country to be traversed. Their positions have been chosen with a view to intersect the greatest number of strata practicable, and in the most advantageous directions for exposing the formation of every geological subdivision of the state. All the principal ridges are crossed nearly at right angles, and an eye has been had to the greater facilities for investigation afforded by the valleys of the large rivers.

As before said, the survey of the zones of country lying along the sections, makes but a portion, and rather the preliminary portion, of the whole survey. In the construction of the map, and the detailed examinations of the systematic survey, the wide tracts of country included between these profiles, would require to be minutely traversed, especially in the longitudinal direction of the strata, to ascertain and depict their boundaries.

A correct knowledge of any region, sufficiently thorough for practical purposes, can only be attained by running from one formation to the neighbouring ones, crossing their boundaries repeatedly in a zigzag course, so as ultimately to cover the whole surface with a net work of lines more or less close, according to the degree of intricacy in the geology of each district; influenced too by the value of the mineral contents of the strata.

It is proposed that the *state cabinet*, which is to grow out of the survey, should be deposited in a suitable apartment in the capitol, accessible to any citizen of the state, seeking the valuable local and specific information which can only be derived from a collection of specimens.

It is contemplated to commence the formation of the cabinet forthwith; that is to say, to accompany each annual report with a suite of specimens illustrative of it—to be grouped according to the most natural order in the mean while, and ultimately to receive a thorough systematic classification.

The specimens ought to consist of the characteristic rocks of each formation, arranged as nearly in the order which they observe in nature as practicable; also the minerals, ores, marls, peculiar soils, organic remains, and other objects to which reference may be desirable by those engaged in agriculture and the arts, or by those who may study the mineral productions of the state, for less specific purposes.

As it is proposed to make a chemical investigation of the composition of these materials an essential feature of the plan, the analyses given in the reports will be annexed to the specimens examined, that thus every one consulting the cabinet may know at the same time the external aspect, and the composition of a substance, capable of useful applications. The analyses essential to this, not the least useful part of the survey, from the arduous nature of the task, will be confined to substances of more immediate interest and utility.

GLOSSARY

OF GEOLOGICAL AND OTHER SCIENTIFIC TERMS.

FROM LYELL'S PRINCIPLES OF GEOLOGY.

Alluvium. Earth, sand, gravel, stones, and other transported matter which has been washed away and thrown down by rivers, floods, or other causes, upon land not *permanently* submerged beneath the waters of lakes or seas. *Etym.*, *alluo*, to wash upon.

Amorphous. Bodies devoid of regular form. *Etym.*, *a*, *a*, without, and *μορφη*, *morphe*, form.

Amygdaloid. One of the forms of the Trap-rocks, in which agates and simple minerals appear to be scattered like almonds in a cake. *Etym.*, *αμυγδαλα*, *amygdala*, an almond.

Analcime. A simple mineral of the Zeolite family also called Cubizite, of frequent occurrence in the trap-rocks.

Anticlinal Axis. If a range of hills, or a valley, be composed of strata, which on the two sides dip in opposite directions, the imaginary line that lies between them, towards which the strata on each side rise, is called the anticlinal axis. In a row of houses with steep roofs facing the south, the slates represent inclined strata dipping north and south, and the ridge is an east and west anticlinal axis.

Arenaceous. Sandy. *Etym.*, *arena*, sand.

Argillaceous. Clayey, composed of clay. *Etym.*, *argilla*, clay.

Arragonite. A simple mineral, a variety of carbonate of lime, so called from having been first found in Arragon, in Spain.

Augite. A simple mineral of a dark green or black colour, which forms a constituent part of many varieties of volcanic rocks.

Basalt. One of the most common varieties of the Trap-rocks. It is a dark green or black stone, composed of augite and felspar, very compact in texture, and of considerable hardness, often found in regular pillars of three or more sides, called basaltic

columns. Remarkable examples of this kind are seen at the Giant's Causeway, in Ireland, and at Fingal's Cave, in Staffa, one of the Hebrides. The term is used by Pliny, and is said to come from *basal*, an Æthiopian word signifying iron. The rock often contains much iron.

"*Basin*" of Paris, "*Basin*" of London. Deposits lying in a hollow or trough, formed of older rocks, sometimes used in geology almost synonymously with "formations" to express the deposits lying in a certain cavity or depression in older rocks.

Belemnite. An extinct genus of the order of molluscous animals called Cephalopoda, having a long, straight, and chambered conical shell. *Etym.*, βελεμνον *belemnion*, a dart.

Bitumen. Mineral pitch, of which the tar-like substance which is often seen to ooze out of the Newcastle coal when on the fire, and which makes it cake, is a good example. *Etym.*, *bitumen*, pitch.

Bituminous Shale. An argillaceous shale, much impregnated with bitumen, which is very common in the coal measures.

Blende. A metallic ore, a compound of the metallic zinc with sulphur. It is often found in brown shining crystals, hence its name among the German miners, from the word *blenden*, to dazzle.

Botryoidal. Resembling a bunch of grapes. *Etym.*, βοτρυς, *botrys*, a bunch of grapes, and εἶδος *eidos*, form.

Boulders. A provincial term for large rounded blocks of stone lying on the surface of the ground, or sometimes imbedded in loose soil, different in composition from the rocks in their vicinity, and which have been therefore transported from a distance.

Breccia. A rock composed of angular fragments connected together by lime or other mineral substance. An Italian term.

Calc Sinter. A German name for the deposits from springs holding carbonate of lime in solution—petrifying springs. *Etym.*, *kalk*, lime, *sintern*, to drop.

Calcareous Rock. Limestone. *Etym.*, *calx*, lime.

Calcareous Spar. Crystallized carbonate of lime.

Calcedony. A silicious simple mineral, uncrystallized. Agates are partly composed of calcedony.

Carbon. An undecomposed inflammable substance, one of the simple elementary bodies. Charcoal is almost entirely composed of it. *Etym.*, *carbo*, coal.

Carbonate of Lime. Lime combines with great avidity with carbonic acid, a gaseous acid only obtained fluid when united with water,—and all combinations of it with other substances are called *Carbonates*. All limestones are carbonates of lime, and quick lime is obtained by driving off the carbonic acid by heat.

Carbonic Acid Gas. A natural gas which often issues from the ground, especially in volcanic countries. *Etym.*, *carbo*, coal, because the gas is obtained by the slow burning of charcoal.

Carboniferous. A term usually applied, in a technical sense, to an ancient group of secondary strata, but any bed containing coal may be said to be carboniferous. *Etym.*, *carbo*, coal, and *fero*, to bear.

Cephalopoda. A class of molluscous animals, having their organs of motion arranged round their head. *Etym.*, κεφαλη, *cephale*, a head, and ποδα, *poda*, feet.

Cetacea. An order of vertebrated mammiferous animals inhabiting the sea. The whale, dolphin, and narwal, are examples. *Etym.*, *cete*, whale.

Chalk. A white earthy limestone, the uppermost of the secondary series of strata.

Chert. A silicious mineral, nearly allied to calcedony and flint, but less homogeneous and simple in texture. A gradual passage from chert to limestone is not uncommon.

Chloritic Sand. Sand coloured green by an admixture of the simple mineral chlorite. *Etym.*, χλωρος, *chloros*, green.

Clinkstone, called also phonolite, a felspathic rock of the Trap family, usually fissile. It is sonorous when struck with a hammer, whence its name.

Coal Formation. This term is generally understood to mean the same as the Coal Measures. There are, however, “coal formations” in all the geological periods, wherever any of the varieties of coal form a principal constituent part of a group of strata.

Conformable. When the planes of one set of strata are generally

parallel to those of another set which are in contact, they are said to be conformable.

Conglomerate or Puddingstone. Rounded water-worn fragments of rock or pebbles, cemented together by another mineral substance, which may be of a silicious, calcareous, or argillaceous nature. *Etym.*, *con*, together, *glomero*, to heap.

Coniferæ. An order of plants which, like the fir and pine, bear cones or tops in which the seeds are contained. *Etym.*, *conus*, cone, and *fero*, to bear.

Crag. A provincial name in Norfolk and Suffolk for a deposit, usually of gravel, belonging to the Older Pliocene period.

Cretaceous. Belonging to chalk. *Etym.*, *creta*, chalk.

Crop Out. A miner's or mineral surveyor's term, to express the rising up or exposure at the surface of a stratum or series of strata.

Crustacea. Animals having a shelly coating or crust which they cast periodically. Crabs, shrimps, and lobsters are examples.

Cryptogamic. A name applied to a class of plants, such as ferns, mosses, sea-weeds, and fungi, in which the fructification or organs of reproduction are concealed. *Etym.*, *κρυπτος*, *kryptos*, concealed, and *γαμος*, *gamos*, marriage.

Crystalline. The internal texture which regular crystals exhibit when broken, or a confused assemblage of ill-defined crystals. Loaf-sugar and statuary-marble have a *crystalline* texture. Sugar-candy and calcareous spar are crystallized.

Debacle. A great rush of waters, which, breaking down all opposing barriers, carries forward the broken fragments of rocks, and spreads them in its course. *Etym.*, *débacler*, French, to unbar, to break up as a river does at the cessation of a long continued frost.

Delta. When a great river, before it enters the sea, divides into separate streams, they often diverge and form two sides of a triangle, the sea being the base. The land included by the three lines, and which is invariably alluvial, was first called, in the case of the Nile, a delta from its resemblance to the letter of the Greek alphabet which goes by that name, Δ. Geologists apply the term to alluvial land formed by a river at its mouth. without reference to its precise shape.

Denudation. The carrying away by the action of running water of a portion of the solid materials of the land, by which inferior rocks are laid bare. *Etym.*, *denudo*, to lay bare.

Dikes. When a mass of the unstratified or igneous rocks, such as granite, trap, and lava, appears as if injected into a great rent in the stratified rocks, cutting across the strata, it forms a dike; and as they are sometimes seen running along the ground, and projecting, like a wall, from the softer strata on both sides of them having wasted away, they are called in the north of England and in Scotland *dikes*, the provincial name for wall. It is not easy to draw the line between dikes and veins. The former are generally of larger dimensions, and have their sides parallel for considerable distances; while veins have generally many ramifications, and these often thin away into slender threads.

Diluvium. Those accumulations of gravel and loose materials which, by some geologists, are said to have been produced by the action of a diluvian wave or deluge sweeping over the surface of the earth. *Etym.*, *diluvium*, deluge.

Dip. When a stratum does not lie horizontally, but is inclined, the point of the compass towards which it sinks is called the dip of the stratum, and the angle it makes with the horizon is called the angle or dip of inclination.

Dolerite. One of the varieties of the trap-rocks, composed of augite and felspar.

Dolomite. A crystalline limestone, containing magnesia as a constituent part. Named after the French geologist Dolomieu.

Dunes. Low hills of blown sand that skirt the shores of Holland, England, Spain, and other countries.

Eocene. The great tertiary era is divided into four periods, the first of which is called *Eocene*, *Εως*, *aurora*, and *Καινος*, *recent*, indicating that in the beds of this division, we see the first traces or *dawn* of the present order of things. The class of fossils most serviceable in determining the relations of the existing to the extinct species, are *shells*, and it is between these, more particularly that the comparison has been made. Out of about 1200 shells discovered in Europe in this lower division of the tertiary rocks, 38 only are identical with species known to be

living. This small proportion (about 3 per cent.) varies a little, of course, with the deposits of different regions ; and the deposits of this formation, like those of any other are characterised less by the *precise* proportion of their extinct fossils, than by possessing a number of shells peculiar to the particular era, and found in no other tertiary groups.

Estuaries. Inlets of the land, which are entered both by rivers and the tides of the sea. Thus we have the estuaries of the Thames, Severn, Tay, &c. *Etym.* *æstus*, the tide.

Fault, in the language of Miners, is the sudden interruption of the continuity of strata in the same plane, accompanied by a crack or fissure varying in width from a mere line to several feet, which is generally filled with broken stone, clay, &c.

Felspar. A simple mineral, which, next to quartz, constitutes the chief material of rocks. The white angular portions in granite are felspar.

Ferruginous. Anything containing iron. *Etym.*, *ferrum* iron.

Formation. A group, whether of alluvial deposits, sedimentary strata, or igneous rocks, referred to a common origin or period.

Fossil. All minerals used to be called fossils, but geologists now use the word only to express the remains of animals and plants found buried in the earth. *Etym.*, *fossilis*, anything that may be dug out of the earth.

Galena, a metallic ore, a compound of lead and sulphur. It has often the high appearance of highly polished lead. *Etym.*, γαλέω, *galeo*, to shine.

Garnet. A simple mineral generally of a deep red colour, crystallized, most commonly met with in mica slate, but also in granite and other igneous rocks.

Gault. A provincial name in the east of England for a series of beds of clay and marl, the geological position of which is between the upper and lower greensand.

Gneiss. A stratified primary rock, composed of the same materials as granite, but having usually a larger proportion of mica, and a laminated texture. The word is a German miner's term.

Granite. An unstratified or igneous rock, generally found inferior to or associated with the oldest of the stratified rocks, and

sometimes penetrating them in the form of dikes and veins. It is usually composed of three simple minerals, felspar, quartz, and mica, and derives its name from having a coarse *granular* structure; *granum*, Latin for grain.

Graywacke. *Grauwacke*, a German name, generally adopted by geologists for the lowest members of the secondary strata. The rock is very often of a gray colour, hence the name, *grau*, being German for gray, and *wacke* being a provincial miner's term.

Greensand. Beds of sand, sandstone, limestone, belonging to the Cretaceous period. The name is given to these beds because they often, but not always, contain an abundance of green earth or chlorite scattered through the substance of the sandstone, limestone, &c.

Greenstone, a variety of trap, composed of hornblende and felspar.

Grit, a provincial name for a coarse-grained sandstone.

Gypsum, a mineral composed of lime and sulphuric acid, hence called also *sulphate of lime*. Plaster and stucco are obtained by exposing gypsum to a strong heat. It is found so abundantly near Paris, that Paris plaster is a common term in this country for the white powder of which casts are made. The term is used by Pliny for a stone used for the same purposes by the ancients. The derivation is unknown.

Hornblende, a simple mineral of a dark green or black colour, which enters largely into the composition of several varieties of the trap rocks.

Hornstone. A silicious mineral substance sometimes approaching nearly to flint, or common quartz. It has a conchoidal fracture, and is infusible, which distinguishes it from compact felspar.

Jura Limestone. The limestones belonging to the oolitic group, constitute the chief part of the mountains of the Jura, between France and Switzerland, and hence the geologists of the Continent have given the name to the group.

Laminæ. Latin for plates; used in geology, for the smaller layers of which a stratum is frequently composed.

Lava. The stone which flows in a melted state from a volcano.

Lias. A provincial name, adopted in scientific language, for a particular kind of limestone, which, being characterised together with its associated beds, by peculiar fossils, forms a particular group of the secondary strata.

Lignite. Wood converted into a kind of coal. *Etym.*, *lignum*, wood.

Lithological. A term expressing the stony structure or character of a mineral mass. We speak of the lithological character of a stratum as distinguished from its zoological character. *Etym.*, *λίθος*, *lithos*, stone, and *λογος*, *logos*, discourse.

Littoral. Belonging to the shore *Etym.*, *littus*, the shore.

Loam. A mixture of sand and clay.

Madrepore. A genus of corals, but generally applied to all the corals distinguished by superficial star-shaped cavities. There are several fossil species.

Mammillary. A surface which is studded over with rounded projections. *Etym.*, *mammilla*, a little breast or pap.

Mammoth. An extinct species of the elephant (*E. primigenius*), of which the fossil bones are frequently met with in various countries. The name is of Tartar origin, and is used in Siberia for animals that burrow under ground.

Marl. A mixture of clay and lime; usually soft, but sometimes hard, in which case it is called indurated marl.

Mastodon. A genus of fossil extinct quadrupeds allied to the elephant. So called from the form of the hind teeth or grinders, which have their surface covered with conical mammillary crests. *Etym.*, *μαστος*, *mastos*, pap, and *οδων*, *odon*, tooth.

Matrix. If a simple mineral or shell, in place of being detached, be still fixed in a portion of rock, it is said to be in its matrix.

Matrix, womb.

Mechanical Origin, Rocks of. Rocks composed of sand, pebbles, or fragments, are so called, to distinguish them from those of a uniform crystalline texture, which are of chemical origin.

Mica. A simple mineral, having a shining silvery surface, and capable of being split into very thin elastic leaves or scales. It is often called *talc* in common life, but mineralogists apply the term *talc* to a different mineral. The brilliant scales in granite are mica. *Etym.*, *mico*, to shine.

Mica-Slate, Mica-Schist, Micaceous Schistus. One of the lowest of the stratified rocks, belonging to the hypogene or primary class, which is characterised by being composed of a large proportion of mica, united with quartz.

Miocene. This is the period next succeeding the eocene, and embraces a larger share of recent or living species among the organic remains. It is called miocene from μειων, *less*, and καινος, *recent*, implying that the formations in question contain *less* recent than extinct species; or in other words, that the living races are a *minority*. Out of 1021 shells in Europe, 176 only belong to animals now living, making the proportion of the recent species about 18 per cent.

Mollusca, Molluscous Animals. Animals, such as shell-fish, which, being devoid of bones, have soft bodies. *Etym., mollis, soft.*

Mountain Limestone. A series of limestone strata, of which the geological position is immediately below the coal-measures, and with which they also sometimes alternate.

Muriate of Soda. The scientific name for common culinary salt because it is composed of muriatic acid and the alkali soda.

New Red Sandstone. A series of sandy, argillaceous, and often calcareous strata, the predominant colour of which is brick-red, but containing portions which are of a greenish-gray. These occur often in spots and stripes, so that the series has sometimes been called the variegated sandstone. The European formation so called lies in a geological position immediately above the coal-measures.

Nodule. A rounded irregular-shaped lump or mass. *Etym.,* diminutive of *nodus*, knot.

Old Red Sandstone. A stratified rock belonging to the Carboniferous group (of Europe.)

Oolite, Oolitic. A limestone, so named because it is composed of rounded particles, like the roe or eggs of a fish. The name is also applied to a large group of strata, characterised by peculiar fossils, because limestone of this kind occurs in this group in England, France, &c. *Etym.,* ωον, *oon*, egg, and λιθος, *lithos*, stone.

Organic Remains. The remains of animals and plants (*organized* bodies) found in a fossil state.

Orthocerata, or Orthocera. An extinct genus of the order of Molluscous animals, called Cephalopoda, that inhabited a long cham-

bered conical shell, like a straight horn. *Etym.*, ὀρθός, *orthos*, straight, and κέρας, *ceras*, horn.

Outliers. When a portion of a stratum occurs at some distance, detached from the general mass of the formation to which it belongs, some practical mineral surveyors call it an *outlier*, and the term is adopted in geological language.

Oxide. The combination of a metal with oxygen; rust is oxide of iron.

Oxygen. One of the constituent parts of the air of the atmosphere; that part which supports life. For a further explanation of the word, consult elementary works on chemistry.

Pelagian, Pelagic. Belonging to the deep sea. *Etym.*, *pelagus*, sea.

Petroleum. A liquid mineral pitch, so called because it is seen to ooze like oil out of the rock. *Etym.*, *petra*, rock, and *oleum*, oil.

Pisolite. A stone possessing a structure like an agglutination of peas. *Etym.*, πῖσον, *pison*, pea, and λίθος, *lithos*, stone.

Pit Coal. Ordinary coal; called so because it is obtained by sinking pits in the ground.

Pitch Stone. A rock of a uniform texture, belonging to the unstratified and volcanic classes, which has an unctuous appearance like indurated pitch.

Pliocene. This is derived from πλείων, *more*, and καινός, *recent*, and is founded upon the existence, in the beds which it embraces, of a greater number of recent than extinct species. The pliocene rocks are referred to two periods, the Older Pliocene and Newer Pliocene; In the newer pliocene, the number of extinct species is extremely small.

Plutonic Rocks. Granite, porphyry, and other igneous rocks, supposed to have consolidated from a melted state at a great depth from the surface.

Porphyry. An unstratified or igneous rock. The term is as old as the time of Pliny, and was applied to a red rock with small angular white bodies diffused through it, which are crystallized felspar, brought from Egypt. The term is hence applied to every species of unstratified rock in which detached crystals of felspar are diffused through a base of other mineral composition. *Etym.*, πορφύρα, *porphyra*, purple.

Precipitate. Substances which having been dissolved in a fluid, are separated from it by combining chemically and forming a solid which falls to the bottom of the fluid. This process is the opposite to that of chemical solution.

Producta. An extinct genus of fossil bivalve shells, occurring only in the older secondary rocks. It is closely allied to the living genus *Terebratula*.

Pyrites. (Iron.) A compound of sulphur and iron, found usually in yellow shining crystals like brass, and in almost every rock stratified and unstratified. The shining metallic bodies, so often seen in common roofing slate, are a familiar example of the mineral. The word is Greek, and comes from *πυρ*, *pyr*, fire, because, under particular circumstances, the stone produces spontaneous heat and even inflammation.

Quartz. A German provincial term, universally adopted in scientific language, for a simple mineral composed of pure silex, or earth of flints: rock-crystal is an example.

Sandstone. Any stone which is composed of an agglutination of grains of sand, whether calcareous, silicious, or of any other mineral nature.

Saurian. Any animal belonging to the lizard tribe. *Etym.* *σαυρα*, *saura*, a lizard.

Schist. Synonymous with slate. *Etym.*, *Schistus*, adj. Latin; that which may be split, from the facility with which slaty rocks may be split into thin plates.

Seams. Thin layers which separate two strata of greater magnitude.

Secondary Strata. An extensive series of the stratified rocks which compose the crust of the globe, with certain characters in common, which distinguish them from another series below them, called *primary*, and from a third series above them called *tertiary*.

Sedimentary Rocks, are those which have been formed by their materials having been thrown down from a state of suspension or solution in water.

Selenite. Crystallized gypsum, or sulphate of lime—a simple mineral.

Serpentine. A rock usually containing much magnesian earth, for the most part unstratified, but sometimes appearing to be an

altered or metamorphic stratified rock. Its name is derived from frequently presenting contrasts of colour, like the skin of some serpents.

Shale. A provincial term, adopted by geologists, to express an indurated slaty clay. *Etym.*, German *schalen*, to peel, to split.

Shell Marl. A deposit of clay, peat, and other substances mixed with shells, which collects at the bottom of lakes.

Shingle. The loose and completely water-worn gravel on the sea-shore.

Silex. The name of one of the pure earths, being the Latin word for *flint*, which is wholly composed of that earth. French geologists have applied it as a generic name for all minerals composed entirely of that earth, of which there are many of different external forms.

Silicious. Of or belonging to the earth of flint. *Etym.*, *silex*, which see. A silicious rock is one mainly composed of silex.

Silt. The more comminuted sand, clay, and earth, which is transported by running water. It is often accumulated by currents in banks. Thus the mouth of a river is silted up when its entrance into the sea is impeded by such accumulation of loose materials.

Simple Mineral. Individual mineral substances, as distinguished from the rocks, which last are usually an aggregation of simple minerals. They are not simple in regard to their nature, for, when subjected to chemical analysis, they are found to consist of a variety of different substances. Pyrites is a simple mineral in the sense we use the term, but it is a chemical compound of sulphur and iron.

Stalactite. When water holding lime in solution deposits it as it drops from the roof of a cavern, long rods of stone hang down like icicles, and these are called *stalactites*. *Etym.*, σταλαζω, *stalazo*, to drop.

Stalagmite. When water holding lime in solution drops on the floor of a cavern, the water evaporating leaves a crust composed of layers of limestone: such a crust is called *stalagmite*, from σταλαγμα, *stalagma*, a drop, in opposition to *stalactite*, which see.

Stilbite. A crystallized simple mineral, usually white, one of the Zeolite family, frequently included in the mass of the trap rocks.

Strata, Stratum. When several rocks lie like the leaves of a book, one upon another, each individual forms a *stratum*; —strata is the plural of the word. *Etym.*, *stratum*, part of a Latin verb signifying to strew or lay out.

Strike. The direction or line of bearing of strata, which is always at right angles to their prevailing dip.

Syenite. A kind of granite, so called because it was brought from Syene in Egypt.

Synclinal Axis. When the strata dip in opposite directions towards a common central imaginary line, it is called a synclinal line or axis.

Talus. When fragments are broken off by the action of the weather from the face of a steep rock, as they accumulate at its foot, they form a sloping heap, called a talus. The term is borrowed from the language of fortification, where *talus* means the outside of a wall of which the thickness is diminished by degrees, as it rises in height, to make it the firmer.

Tertiary Strata. A series of sedimentary rocks, with characters which distinguish them from two other great series of strata,—the secondary and primary, which lie *beneath* them.

Testacea. Molluscous animals, having a shelly covering. *Etym.*, *testa*, a shell, such as snails, whelks, oysters, &c.

Thin out. When a stratum, in the course of its prolongation in any direction, becomes gradually less in thickness, the two surfaces approach nearer and nearer; and when at last they meet, the stratum is said to thin out, or disappear.

Trap and Trappean Rocks. Volcanic rocks composed of felspar, augite, and hornblende. The various proportions and state of aggregation of these simple minerals, and differences in external forms, give rise to varieties, which have received distinct appellations, such as basalt, amygdaloid, dolorite, greenstone, and others. The term is derived from *trappa*, a Swedish word for stair, because the rocks of this class often occur in large tabular masses, rising one above another, like the steps of a staircase.

Travertin. A concretionary limestone, usually hard and semi-crystalline, deposited from the water of springs holding lime in solution. *Ety.* This stone was called by the ancients *Lapis Tiburtinus*, the stone being formed in great quantity by the river Anio, at Tibur, near Rome. Some suppose travertin to be an abbreviation of *trasteverino* from *trans-tiburtinus*.

Tuff or *Tufa.* An Italian name for a variety of volcanic rock of an earthy texture, seldom very compact, and composed of an agglutination of fragments of scoriæ, and loose matter ejected from a volcano.

Turbinated. Shells which have a spiral or screw-form structure. *Ety.*, *turbinatus*, made like a top.

Unconformable. See *Conformable*.

Veins, Mineral. Cracks in rocks filled up by substances different from the rock, which may either be earthy or metallic. Veins are sometimes many yards wide; and they ramify or branch off into innumerable smaller parts, often as slender as threads, like the veins in an animal, and hence their name.

Wacke. A rock nearly allied to basalt, of which it may be regarded as a soft and earthy variety.

Zeolite. A family of simple minerals, including stilbite, mesotype, analcime, and some others, usually found in the trap or volcanic rocks. Some of the most common varieties swell or boil up when exposed to the blow-pipe, and hence the name $\zeta\epsilon\omega$, *zeo*, to boil, and $\lambda\iota\theta\omicron\varsigma$, *lithos*, stone.

Zoophytes. Corals, sponges, and other aquatic animals allied to them, so called because, while they are the habitation of animals, they are fixed to the ground, and have the forms of plants. *Ety.*, $\zeta\omicron\omicron\nu$, *zoon*, animal, and $\phi\upsilon\tau\omicron\nu$, *phyton*, plant.

ERRATA.

Insert a comma after *above*, in line 24, page 17.

Add an s to *limestone*, in line 26, page 30.

For *strata*, read *stratum*, in 3rd line from bottom, page 35.

Dele the word *which*, in line 26 of page 104.

For *becomes*, read *become*, in line 12, page 105.

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V2r

PROFILE
to accompany
the Geological Reconnoissance
of the
STATE of VIRGINIA
by
PROF. WILLIAM B. ROGERS.
1836.

Limestone		Quartz Vein		Amygdaloid	
Sandstone		Quartz		Shale	
Conglomerate		Felspar		Iron Ore	
Slate		Mica		Sandstone very Crystalline	
Coal		Talc		Arenaceous or Siliceous Limestone	
Sand and Gravel		Hornblende		Ditto Slate	

Horizontal Scale of Miles
0 1 2 3 4 5 6 7 8



group fills the Space between the Ohio and the top of Little Sewell; Much of the rock is very Saliferous, especially in the inferior beds; near the middle of the Series are many good beds of Bituminous Coal; and from Elk River west occasional thin Strata of fossiliferous Limestone and Hydraulic Cement

Even here west the Sandstones differ from those of the Allegheny, & the want of accordance in dip marks perhaps the beginning of the Great Western

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PHYSICAL STRUCTURE OF APPALACHIAN CHAIN.

Plate No. III.



SECTION A.

From the Allegheny Mt, Luzerne Co. Penn^a to the South Mt in Berks County.

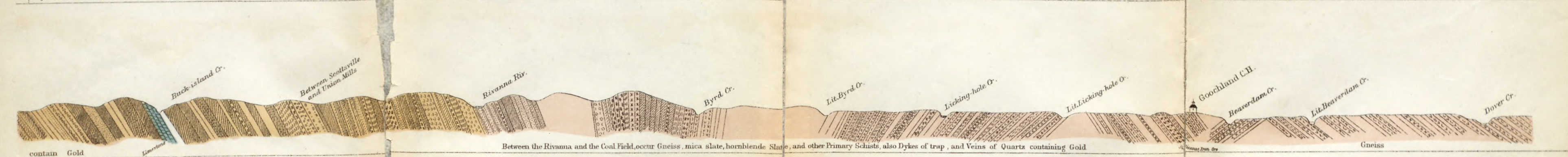
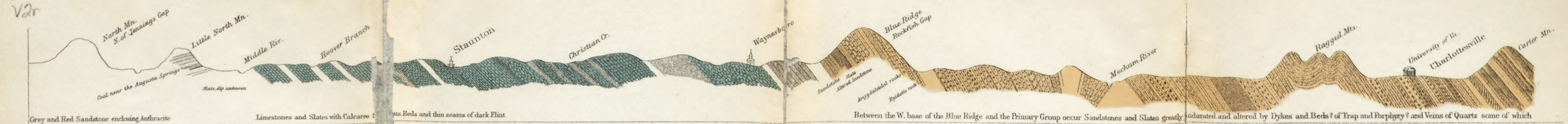
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V2r



Virginia Geological Sections
Constructed by Wm. B. Rogers,
Director of the Virginia Geological Survey, 1835-41:
Edited by Jed. Hotchkiss, 1883-84.

Throughout this Section the lowest rock is a grey and red fossiliferous Sandstone, upon this a thin bedded fossiliferous Limestone, being Sometimes a Calcareous Sandstone, over this a thick group of fossiliferous brown Slates and Slaty Sandstones

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V2r



PROF. WILLIAM B. ROGERS.
the Geological Reconnaissance
of the
STATE OF VIRGINIA.

Scale half an inch to a mile

Limestone	Quartz Vein	Amygdaloid
Sandstone	Quartz	Shale
Conglomerate	Felspar	Iron Ore
Slate	Mica	Sandstone very Crystalline
Coal	Talc	Arenaceous or Siliceous Limest.
Sand and Gravel	Hornblende	Ditto Slate

Library of the U.S. Geol. Surv.



group fills the space between the Ohio and the top of Little Sewell. Much of the rock is very Saliferous, especially in the inferior beds; near the middle of the Series are many good beds of Bituminous Coal, and from Elk river west occasional thin strata of fossiliferous Limestone and Hydraulic Cement.

Throughout this Section the lowest rock is a grey and red fossiliferous Sandstone; upon this a thin fossiliferous Limestone, being sometimes a Calcareous Sandstone; over this a thick group of fossiliferous brown Slates and Slaty Sandstones.

Grey and Red Sandstone enclosing Anthracite.

Limestones and Slates with Calcareous Siliceous Beds and thin seams of dark Flint

Between the W. base of the Blue Ridge and the Primary Group, occur Sandstones and Slates greatly indurated and altered by Dykes and Beds of Trap and Porphyry and Veins of Quartz. Some of which

contain Gold.

Between the Rappahannock and the Coal Field, occur Gneiss, mica slate, hornblende Slate, and other Primary Schists also Dykes of trap, and Veins of Quartz containing Gold.

Gneiss

Bituminous Coal Field.

Gneiss

Sandstone

Eocene Green Sand.

The lower stratum is Miocene Shell Marl; the upper stratum is Diluvial Sand and Gravel.